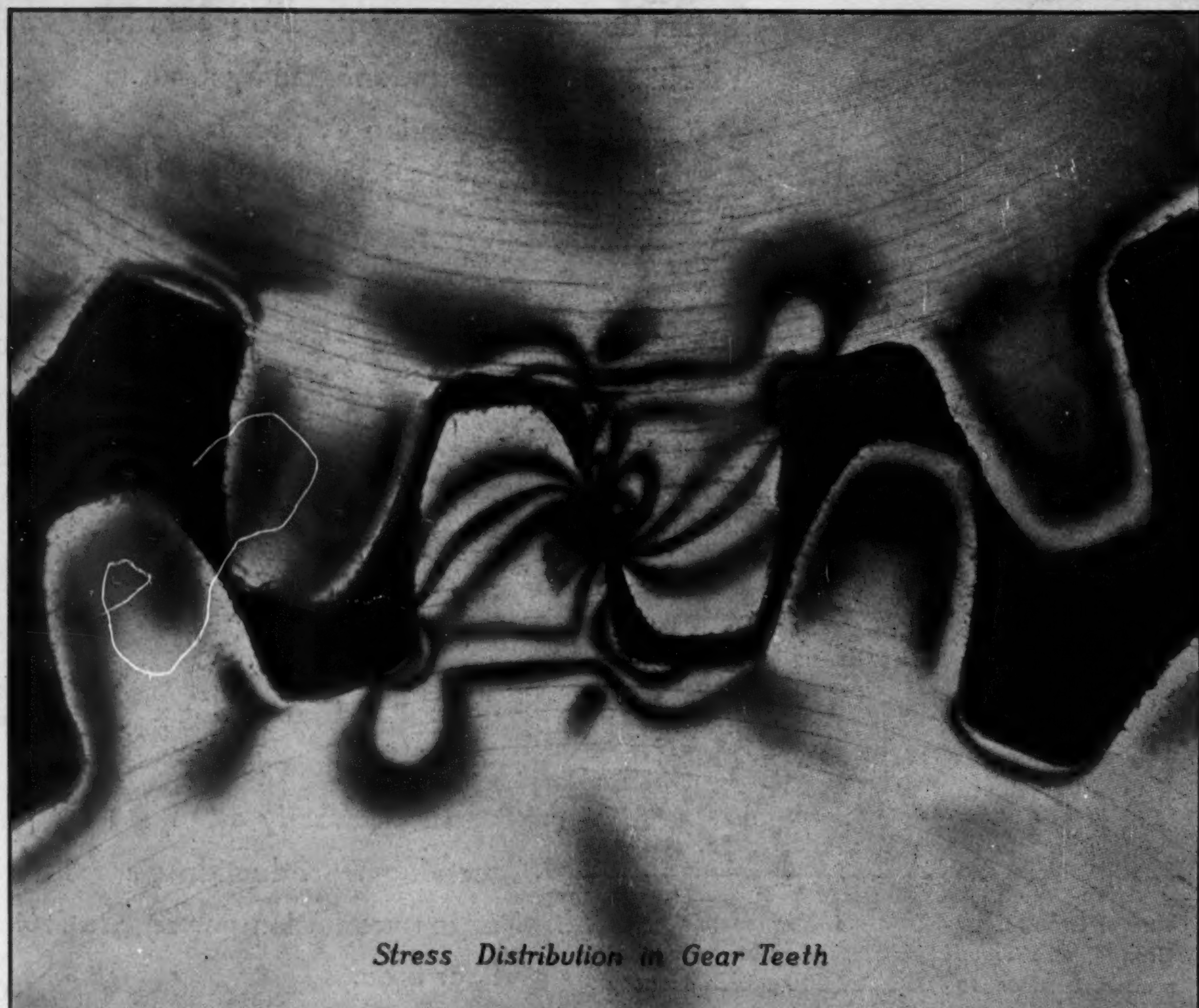
IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING



Stress Distribution in Gear Teeth

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

September 1929

A TRIBUTE TO RELIABILITY

New York Steam Obtains Grand Central Contract

To Supply Group of Buildings; Road Abandons Own Plants

Arrangements to supply the entire steam requirements of 1,500,000,000 pounds annually to the Grand Central group of buildings have been completed by the New York Steam Corporation. The buildings included in the group extend from Forty-second to Fiftieth Streets and from Madison to Lexington Avenues, according to the statement issued by the corporation yesterday.

With the addition of the Grand Central group, the New York Steam Corporation will supply practically every important building in the midtown section.

The buildings included in the Grand Central group either are owned by the New York Central Railroad Company or have been erected by others on property leased from the railroad company for a long term of years. For some years the major steam requirements of the buildings have been supplied from two large steam generating stations owned and operated by the railroad company and located at Park Avenue and Fiftieth Street and at Lexington Avenue and Forty-third Street. Steam has been distributed through a system of pipe lines occupying land privately owned by the railroad company. The railroad company has been maintaining a break-down service contract with the New York Steam Corporation to insure continuity of service.

After a thorough study of the reliability of the steam corporation's service and an analysis of costs, the railroad company has decided to abandon its two stations and, together with the New York, New Haven & Hartford Railroad, has entered into a contract with the New York Steam Corporation.

View of Grand Central Zone, New York, containing the Grand Central Group of buildings whose steam requirements will amount to 1,500,000,000 pounds annually

"a thorough study of the reliability of the steam corporation's service"

The decision of the New York Central to abandon existing power plants and contract with the New York Steam Corporation for service, is a great tribute to the reliability of the service furnished by this company.

Combustion Engineering Corporation, has for many years, supplied fuel burning and steam generating equipment to the New York Steam Corporation.

In the Kip's Bay Station, their nearest plant to the Grand Central Group of buildings, are installed — C-E Boilers — Ladd Type, Lopulco Pulverized Fuel Systems, C-E Fin Furnaces, C-E Air Preheaters and Raymond Pulverizers.

Kip's Bay Station is designed for an ultimate capacity of approximately 5,000,000 pounds of steam per hour and has already established records for steam production per unit and steam production per square foot of floor area.

COMBUSTION ENGINEERING CORPORATION

International Combustion Building . 200 Madison Avenue, New York, N. Y.

A SUBSIDIARY OF INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

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J. A. Switzer

R. V. Baud

W. L. Batt

R. E. Flanders

R. E. Peterson

Contributors to This Issue

R. E. Flanders, general manager of the Jones & Lamson Machine Co., Springfield, Vt., served his apprenticeship at the Brown & Sharpe Manufacturing Co., Providence, R. I. During his professional career Mr. Flanders has been connected with the Taft-Pierce Manufacturing Co., the International Paper Box Machine Co., the General Electric Co., *Machinery* of New York, and the Fellows Gear Shaper Co., and since 1912 with the Jones & Lamson Machine Co. He is a recognized authority on both machine-tool design and shop management and is the author of a book on "Gear-Cutting Machinery" as well as of many technical papers.

R. V. Baud, in charge of photoelastic work in the research department of the Westinghouse Electric & Manufacturing Co. for the past four years, was graduated in 1920 from the Technical University in Zurich. Prior to joining the Westinghouse Co., he was connected with the German General Electric Co., being engaged in their offices at Berlin and Sao Paulo on power-plant work.

R. E. Peterson of the research department of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., received his B.S. in mechanical engineering from the University of Illinois in 1925, and one year later his M.S. in theoretical and applied mechanics from the same institution. In September, 1926, he entered the employment of the Westinghouse Co. in the railway-motor engineering department and in January, 1928, was transferred to the research department. For the past three years he has also been part-time instructor in analytical mechanics and strength of materials at Carnegie Institute of Technology.

R. R. Bottoms, director of research, the Helium Co., Louisville, Ky., was attending the University of Michigan in 1916 when he left to enter the field of naval aviation. He was assigned to the Naval Air Station at Rockaway Beach, Long Island, and was there put in charge of hydrogen production. The year 1918 he spent at Goodyear Field in Akron, Ohio, training hydrogen officers; early the following year he was transferred to Key West for dirigible training. From 1921 to 1927 he had charge of the helium-purification plant of the Naval Air Station at Lakehurst, N. J. Mr. Bottoms designed and built the Helium Company's production plant at Dexter, Kansas, in 1927.

H. W. McQuaid, metallurgist, the Timken Detroit Axle Co., Detroit, Mich., was graduated from Stevens Institute of Technology in 1913 and for the past fifteen years has been connected with the steel industry. For eleven years he was associated with the Timken Roller Bearing Co., five of them as metallurgist. For the past three years he has been in the service of the Timken Detroit Axle Co.

C. V. Foulds was graduated from the University of California in mechanical engineering in 1916 and in September entered the service of the Pelton Water Wheel Co., in the engineering department. He then engaged in general engineering installation of Pelton water-wheel equipment for an aluminum company in Norway. Later he spent three years in the installation of Pelton equipment at a large plant in Western India. From 1924 to 1928 he served as engineering assistant and executive engineer of the company, and in 1929 became manager of engineering and operations.

F. M. Jaeger, who is the author of the paper in this issue on "The Present and Future of Our Natural and Energetic Resources," is a professor of chemistry at the University of Groningen, Holland. He was non-resident lecturer in chemistry at Cornell University during the past University term under the George Fisher Baker Foundation.

W. L. Batt, president of SKF industries, New York, N. Y., was graduated from Purdue University in 1907 with the degree of B.S. in mechanical engineering. Subsequently he became associated with the Hess-Bright Manufacturing Co., at Philadelphia, Pa., in the manufacturing, engineering, and sales of anti-friction bearings. In 1917 he became general manager of the company and following the consolidation of SKF Ball Bearing Co., Hess-Bright Manufacturing Co., Atlas Ball Co., and other organizations, became vice-president of SKF Industries, Inc., the central organization. He is also chairman of the board of the Air Preheater Corporation and a director of the Hudson Insurance Co.

J. A. Switzer, after studying at the University of Wisconsin and at Cornell University, was graduated from the latter in 1896 with the degree of M.E. In 1908 he accepted a professorship at the University of Tennessee. Since its beginning in 1910, he has been on the staff of the Tennessee State Geological Survey as hydraulic engineer. In 1918 he read a paper before the American Electrochemical Society on "The Larger Undeveloped Water-powers of Tennessee." This paper was one of the important contributary causes of the appropriation which Congress made for the Survey of the Tennessee River, a survey which has cost over a million dollars.

This Month's Cover is reproduced from a photograph of a celluloid model of a gear which has been subjected to a beam of polarized light, the bands of coloring showing concentrations of stresses due to the pressures transmitted by the teeth. It is used in connection with the paper in this issue by R. V. Baud and R. E. Peterson on "Load and Stress Cycles in Gear Teeth."

MECHANICAL ENGINEERING

Volume 51 September, 1929 No. 9

Engineering and the Human Values

By RALPH E. FLANDERS,[1] SPRINGFIELD, VT.

IT IS A PLEASANT circumstance that there is met here tonight a mingled group of engineers and students—of men who have spent years in the practice of their profession, side by side with those intent on scholastic preparation.

The topic that I have in mind to discuss with you relates to the fundamental values of the engineer's work. Is human life in any sense deeper and richer for our present dominant influence upon it? Can we make contributions to it of our own peculiar kind that will deepen and enrich its future course?

Such questionings are not perhaps natural to the engineering student. He is busy with his groundwork in mathematics, physics, chemistry, and mechanics. He looks forward, perhaps with some doubt, to the nature and success of his contacts with the world of business into which he is so soon to be thrown. There come to him, there perhaps should come to him, no premature questionings as to the value of the life work he has chosen.

But it is not so with many of us who are older, nor will it surely be so always with you. For there are many voices in the air—voices of artists, moralists, literary men, social students, philosophers, historians—voices of those whose chief aim is not to do (which is presumably our preoccupation), but to see and to think; and from the confused murmur of this mass of voices there can be detected a general, dominant note of dissatisfaction and accusation, leveled at the concrete form into which we, the engineers, have molded the world.

"Man cannot live by bread alone." No measure of practical achievement, of professional reputation, or of financial reward will serve to content the spirit of the engineer if he himself becomes imbued with the doubts which his critics express so strongly and persistently. In due course of time these doubts, if left unresolved, will beat also upon you who are now students. It is just possible that a very great contribution can be made toward the future happiness of some of you by pausing for a few minutes here tonight, in the midst of your preparation, to face and question the forces that are being directed against our spiritual foundations.

Elements Giving Ultimate Values to Human Life

There have been many attempts, in many creeds and numerous philosophies, to list or describe the elements which give ultimate values to human life. We might spend not an evening but a lifetime discussing this matter. Let us be arbitrary, therefore, and accept the old-fashioned categories of beauty, truth, and goodness as a useful description of these values. To what extent has our engineering civilization destroyed, preserved, or augmented them in the past? What hope is there for a continued progress in the future?

When our mechanical civilization faces the problem of beauty, it does not have much to say. We look back upon the architecture, the sculpture, and the literature of Greece; upon the architecture, carving, and handicraft of the Middle Ages; or upon the painting, poetry, music, and literature which filled the centuries from the Renaissance to Stephenson's *Rocket*—and we bow our heads. Those times were crude in physical knowledge, oft times rough and bloody in human relations; but in those times Beauty walked with man, and in just that free, untrammeled companionship she walks no longer.

We have some small items to our credit. There is the clear, cold, fascinating beauty that comes of form adapted to use, seen in the lines of the automobile, the airplane, the steam locomotive, the best of the sky scrapers, and preeminently in the hull and sail-spread of the racing yacht. (How much Gothic architecture owes to this purely engineering beauty has only lately been discovered—so warmly was the structure clothed with sculpture and ornamentation.)

Besides this, we have made a contribution to the enjoyment of the old forms in spreading the knowledge of them by printing, illustration, and world travel. These fundamentally mechanical aids have now begun to crystallize in an actual, general improvement in taste, this being the best recompense we can make for the atrocious artistic barbarisms of the first decades of the industrial age.

In all this there is no efflorescence of creation. The Creative Spirit through the ages rests now here, now there. She lives with us in all her power in the fields of mathematics, physics, mechanics, organization. If for the time she neglects the field of art, shall we complain? Let us rather rejoice alike in her new forms, and in the record of her past incarnations.

In the matter of truth we have a better account to render of ourselves. "What is truth?" asked the hard-boiled Roman governor. Numberless answers have come down the ages. Much has been written by theologians and philosophers meditating in seclusion. Something was contributed by active men of affairs—conclusions drawn from daily contact with men and things. Between these forces there was some agreement—more disagreement. It has remained for the scientist and engineer to put questions to Nature herself and have them answered with an indubitable "yes" or "no."

Not all truth lies thus within our certain jurisdiction. Perhaps what does is not the highest kind of truth; but at least it can be put to the highest uses. When, however, the last reservation is made and the last condition acceded to, the great fact remains that we have learned Nature's language, can ask questions of her, can understand her answers, and can thus govern a large area of our actions by her laws.

Our Growing Ability to Adapt Ourselves to Nature

By this means we are enabled to adapt ourselves to Nature, to control and combat a growing proportion of her manifestations, and in general to be masters of our fate in the physical world in

[1] Manager, Jones & Lamson Machine Co. Mem. A.S.M.E.

Address at banquet during the Knoxville, Tenn., Meeting of the A.S.M.E., March 21 to 23, 1929.

a way and to a degree which has not been possible for any preceding race of men whose records remain to us.

This is our achievement and our glory. The ocean steamship, aseptic surgery, the radio, the Delaware bridge, the weather bureau, and then thousand times ten thousand other products and activities bear witness to it. Those who would belittle or deny the importance of this achievement convince us only of their own distorted vision.

And now, in the hands of men like Eddington, the English astronomer-physicist, this grasp on the truth of nature is being carried on into the highest areas of speculative thought, with—it seems to me—much more hope of approach to ultimate truth in some form than can be expected from the introverted convolutions of pure ratiocination.

What of goodness—that most difficult and evasive of fundamental values? It would appear at first thought to be independent of all non-moral conditions. The subjectively good man can show his qualities in the Oriental bazar, the tropic jungle, or the great Western metropolis equally well. His virtue will probably lead to financial loss and personal discomfort in any surroundings, leaving him the gift of a clear conscience as the worthy recompense.

If, however, we consider active benevolence, the doing of good deeds to and for our fellow-men, we touch on a side of the question which relates particularly to the qualities of our mechanical and industrial civilization. I believe it possible to make the point that our work both can and does effect an amelioration of man's physical distresses.

Humanitarian By-Products of Improvements Primarily Economic

That it can do so scarcely needs argument. In our practical conquest of all the ordinary forces of nature we have a ready and effective tool for benevolence. Pestilence, famine, privation, and ordinary poverty are all within our physical control, barring sudden and cosmic changes which cannot enter into our practical planning. It seems sure that this opportunity for effective benevolence is something quite new, on this planet at least. What use is being made of these powers? Let us examine the record.

In the first place, there is a considerable lessening of discomfort and danger which has come as a by-product of engineering activity, even where the motive was plainly economic rather than humanitarian. An example of this is the application of mechanical stokers and oil firing to stationary, locomotive, and marine boilers. Hells of heat and muscular exertion are being abolished by engineering solutions of economic problems.

Perhaps some of you have stood on an ocean liner while it threaded a devious and respectful way through the fleet of puny trawlers which lie a hundred and fifty miles or so off the mouth of the English Channel. Some of this fleet are steam vessels. They are small, dirty, and crowded, but supplied with shelter and warmth. Most of the trawlers, however, are sailboats, completely open, without cabin or planked deck. They are manned by poor fishermen from the coasts of Ireland and Brittany, who ply their perilous trade on a rough, foggy sea, exposed for days to the storms of winter and the perils of the speeding liners. Such boats, such men, such lives are the raw materials of art; they are another kind of "cannon fodder" for the production of heart-stirring paintings, poetry, and song. The artist-minded man would multiply them and perpetuate their conditions—himself meanwhile comfortably encased in his studio.

Now I know nothing of the economic and spiritual details of the lives of these men, and I may have entirely misjudged the whole situation; but it seeems to me possible that there is some slight advance in human values when the warmth and shelter of the engineer's steam trawler are substituted for the unremitting wet and chill of the little open boat.

Here is another example drawn from the sea, and from the work of the President of our Society, Mr. Elmer Sperry. Until about one hundred and fifty years ago all ships were steered by a tiller, attached directly to the rudder post and exposed to the elements. There was certainly something elemental about the problem of handling a boat in a stormy sea in those old days. Running before the storm, with wave after wave climbing in over the stern, the tiller thrashing to and fro as the boat climbed the crest and dropped into the trough, a band of exhausted and disheartened men struggled against imminent individual and collective disaster—and too often they lost.

Engineering improvements were introduced, slowly at first. The tiller was housed between decks. A primitive steering wheel was mounted on the tiller. Then the wheel was moved forward to a comfortable house, and the ropes extended back to the tiller. Next came the steering engine. Finally, in the fullness of time Mr. Sperry presents us with the device affectionately known among sailors as "Metal Mike," the automatic gyroscopic compass, which only asks to be told the course, and thereupon faithfully holds the ship to it with its own strength and intelligence, irrespective of storms, seas, and magnetic variations.

There is no poetry or song in "Metal Mike." No painter immortalizes his sturdy and self-respecting frame. But his presence implies warmth, shelter, speed, and safety for those who go down to the sea in ships, and is a stirring example of man's mastery of nature; so perhaps the exchange is not to be regretted.

These examples, and numberless others like them, relate to improvements which were not primarily humanitarian but economic. The humanitarian element is a by-product. Such instances are so nearly innumerable that our unregenerate Rotarian race may be excused for confusing service and profit. Perhaps there really is a divine law connecting them!

Engineering Improvements Primarily Humanitarian

The engineering age has, on the other hand, many less equivocal exhibits to offer in support of its claim to benevolence. Much is now being done by engineers that is primarily for the sake of decency, and involves only slight profits, or even actual losses. Let me draw three examples from the incidents of this meeting.

Yesterday there was held a discussion of the problem of smoke abatement, one of the most serious responsibilities that faces the engineer. I was interested to have my friend George Orrok take the stand that the solution of the problem would be greatly delayed if we waited until somebody found how to make smokeless combustion economical in all cases. It is primarily a question of human rather than of money values. This viewpoint was accepted by the engineers present, and is generally adopted by them as the mainspring of their organized and individual action in this important matter.

Again, this morning, on our way out to the Mascot Mine, we came suddenly upon a cement mill. The word "suddenly" is used by intention. It did not used to be possible to approach a cement mill without due warning. Like the *Mephitis mephitica*, it could be detected from afar. For miles around a pall of fine dust hung over grass, flowers, trees, and houses, penetrating clothes and lungs impartially, inescapable as the air we breathe. But the mill we saw this morning is a wet-process mill, clean, and neat, set in a green and smiling country. I understand that there is perhaps a slight economic factor against the old-fashioned and rapidly obsolescing dry mill, but that is not the determining factor in its disappearance. It was outlawed because it defied the human values as appraised by the engineering mind.

At the Mascot Mine, among many other items of interesting and valuable information, we were told of the success of the

Safety First campaign, now several years old. I do not remember whether "time lost" had been reduced to one-tenth or one-hundredth or one-thousandth of the previous figure—the exact fraction is immaterial. It was interesting that the results were put in economic terms, but this need deceive nobody. It is mere protective coloration. No self-respecting unhypocritical engineer likes to get caught in a humanitarian action if he can conceal it in economic camouflage. To any one familiar with such things, and who sized up the personnel of that mine as they gathered to greet us and to bid us good-bye, it was plain that the driving motive for the close and wearing attention to thousands of details which were involved in the event must have been a sense of human decency. The paltry dollars concerned are not worth the effort.

In fact, it seems very clear to me that the engineering education, environment, and outlook either attract men of humanitarian impulses, or furnish a fertile field for those impulses, or both.

Contributions That Engineering Can Make Toward the Dignity and Worth of the Common Man

Let me draw one more example from observation which seems to me to typify the distinctive contribution that engineering can make toward the dignity and worth of the common man.

A few months ago, within the space of one week, I visited two plants in the same line of business, making a tonnage product. They were about the same size, both in floor area and output. Both paid high wages and were financially successful. Here the resemblance ends.

One of those plants was housed in grimy, dirty buildings in a grimy, dirty district. The machinery was of standard types, bought in the open market, and almost entirely hand-operated. The work was moved about the plant for the most part by hand trucking, though some power tractors were employed. To the unaccustomed eye the physical and nervous pace of the plant was terrifying. Everything possible was done by piece work, and under its stimulus mechanized humans of both sexes sat glued to their stools and concentrated every last ounce of energy on their tasks. They were well paid, mind you, probably as highly in some cases as is the ordinary college professor. But their work and its conditions were mechanical and inhuman.

Not so in the other plant. This was equipped with automatically fed machinery, largely designed and built on the premises. Men of no greater capacities and possibilities than their fellows in the first plant went calmly and unhurriedly about their work—masters of the machines they were tending. They inspected the work, adjusted the tools, directed the flow of parts. The transfer of work from machine to machine was entirely mechanical, often automatic. The operatives were cleanly dressed, self-respecting, and serene.

To my mind this contrast presents the immediate contribution which engineering is at this moment prepared to offer to an industrial world. It was not too much engineering but lack of it which made shop No. 1 a distressing spectacle. It was not the absence of engineering but its abounding presence which gave shop No. 2 its atmosphere of human worth. And yet the artist mind would quite likely have been equally revolted by both. It might even have been attracted somewhat to the worse, for it would make a better subject for an etching.

The processes of the artist mind are a puzzle to the engineer. In meditating on the matter I always recall that moronic and blasphemous play of the early nineteen hundreds, "The Servant in the House." Some of the elders will remember it. The younger ones would waste their time in looking it up.

The play centers about an ungodly odor which permeated a fine new church. This odor was cured by the descent into a cesspool of a brother of the highbrow rector, the brother being a cross between a comic-paper plumber and "a night soil man." On his descent he was accompanied by a mysterious stranger from the East, the Servant in the House, who shared in all the filth and ordure, and thereby in some obscure way cleansed the church. This was intended to represent the acme of goodness as seen by the artist mind.

To the engineer mind it represented the acme of incompetence and imbecility. With a properly devised sewage system, and septic tanks or other adequate means of disposal, neither the rector nor the brother nor the Servant would have had to distress themselves with cesspools and sewerage.

Where does effective goodness lie? In sanitary engineering certainly, and not in the neurotic maunderings of the play.

The New Kindliness a Direct By-Product of Engineering Development

In addition to all this impersonal improvement of human conditions, there is developing an actual, active goodness which has been made possible by modern science, engineering, and industry. As Dean Kimball said to me a few months ago, "There is a new kindliness developing between men."

This "new kindliness," as I see it, is a direct by-product of engineering development. So long as individual man, working alone by primitive means, could do little more than win a precarious support for himself and his family, the only way to an increase of goods was by violence and deceit. What A gained must be wrested from B.

The beginnings of the industrial age were grim and loathsome in many places and in many respects. Yet that age brought a corrective principle which may, if we recognize and employ it properly, outmode violence and deceit. When A and B cooperate to employ the tools and organizing power of the engineer, they can produce so much that each can have far more than in the olden times, and still have something left over to pay the engineer with. This principle is in active operation today, particularly in this country.

Owing to the productivity of engineering skill, the output of A and B in many activities may easily be increased a hundred fold. This may be divided with great disparity, giving, say, A ninety fold, the engineer eight fold, while poor B only gets two fold. But in spite of injustice he *does* get two fold anyway.

Furthermore, of course, there are still robbers and parasites outside of productive cooperation (in speculation, for instance) who reduce the shares of A, B, and the engineer alike. But the possibilities for justice are there. There is no grim necessity, as in past ages, for men to act like ravening wolves. It is now possible, if we all use intelligence, patience, and good-will, for this "new kindliness" to spread until it envelops all the healthy and normal activities of mankind. A consummation so glorious is only possible for the large mass of mankind through the intervention of the scientist, the industrial organizer, and, primarily, the engineer.

The Fundamental Human Worth of the Engineer's Profession

I want to close by quoting to you, with approval, a passage from the works of the world's greatest pessimist. May I say that in general there is more stimulation and solid sense to be derived from the thoughts of the great pessimists than from those of the optimists. I do not mean that the pessimists are right and the optimists wrong. The reverse may be the case. The point is that the optimist is too easily satisfied. His thought skims over the surface of things. The pessimist sounds the depths and explores the foundations. He is not the man to be deceived by surface beauty. He is more than likely to bring up from his subaqueous and subterranean expeditions things strange

and terrible, but also true. His only failure may be in the tint of the glass of his Diogenes lantern, which radiates the lines of strangeness and terror over objects which are really desirable.

In the next to the last section of the last chapter of the last volume of that remarkable and portentous book, "The Decline of the West," Oswald Spengler has written this passage:

> The center of the artificial and complicated realm of the machine is the organizer and manager. The mind, not the hand, holds it together. But, for that very reason, to preserve the ever-endangered structure, *one* figure is even more important than all the energy of enterprising master men that makes cities to grow out of the ground and alter the picture of the landscape; it is a figure that is apt to be forgotten in this conflict of politics—the *engineer*, the priest of the machine, the man who knows it. Not merely the importance but the very existence of the industry depends upon the existence of the hundred thousand talented, rigorously schooled brains that command the technique and develop it onward and onward.
>
> The quiet engineer it is who is the machine's master and destiny. His thought is as possibility what the machine is as actuality. There have been fears, thoroughly materialistic fears, of the exhaustion of the coal fields. But as long as there are worthy technical pathfinders, dangers of this sort have no existence.

Let us pause for a moment to catch his meaning. The industrial age will not end with the exhaustion of the beds of coal, iron, petroleum, and oil shale, any more than it depends on the nitrate beds of Chile in the face of the fixation of the atmospheric element. So long as water runs, the sun shines, and the vegetable world proliferates, so long will the engineering mind furnish ample provision for human well-being drawn from the living forces of nature. But to conclude the quotation:

> When, and only when, the crop of recruits for this army fails—this army whose thought-work forms one onward unit with the work of the machine—then industry must flicker out in spite of all that managerial energy and the workers can do. Suppose that, in future generations, the most gifted minds were to find their souls' health more important than all the powers of this world; suppose that, under the influence of the metaphysic and mysticism that is taking the place of rationalism today, the very elite of intellect that is now concerned with the machine comes to be overpowered by a growing sense of its Satanism (it is the step from Roger Bacon to Bernard of Clairvaux)—then nothing can hinder the end of this grand drama that has been a play of intellects, with hands as mere auxiliaries.

Such a decay of interest in and will toward engineering seems remote. Our children and our childrens' children are doubtless safe. But because the situation is real and the danger possible, it has seemed to be worth while tonight to address myself particularly to you engineers of the future in the hope that you might be encouraged, in any coming period of doubt or pessimism, to thoroughly examine the foundations of your profession, and satisfy yourselves as to its fundamental human worth.

The Economic and Social Significance of Engineering

MAN'S stay upon this earth has been one long, hard struggle to subdue his environment and make this planet comfortable as a habitation. Viewed from a present-day standpoint, the history of this effort is not one to fill us with admiration for human mentality. The hopeless poverty and degradation of the working classes in all civilized nations up to the present era, even when surrounded by the finest of natural advantages, is a phenomenon to marvel at. This is particularly so when one considers the high mental development of some of our predecessors. It is difficult to understand why the ancient Greeks, for instance, did not turn the searchlight of their acute reasoning power upon the simple problem of making a decent living. They might have done as much or more for posterity as they have done by their speculative philosophy.

It remained for a few rather humble engineers and inventors to give us a new world. Suddenly and with little warning the Industrial Revolution shattered all old ideas of production, and more slowly, but equally effectively, modern applied science has given us a new conception of the possibilities of supporting human life and of making existence comfortable. The results of these changes are well known to all of you. Whereas the problem of the old nations was to produce enough of the necessities of life to sustain existence, to feed, to clothe and to house the multitude somewhat better than the beasts of the field, our problem is to find out how we can make a surplus of necessities available for all. We are even now producing more than we can intelligently use of most products and if all of our productive processes were put at work upon the necessities of life alone, we would not know what to do with the output. But while the level of existence has been raised considerably there is still much want and much unemployment even for some of those who are able and willing to work. Our problem therefore is no longer one of production but one of distribution. Truly as Bertrand Russell has remarked if there has been hunger and poverty since the Industrial Revolution it is because of ignorance and selfishness. Happy shall we be if some economic Moses arises to show us the way whereby we may use our wonderful productive processes to the end that poverty with all of its accursed concomitants shall be a distant memory.

The hope that there is a solution springs likewise from a consideration of modern scientific and industrial methods. One of the most important contributions that modern science and industry have conferred upon us is to instill firmly into our minds the idea of *progress*. The philosophic outlook of the eighteenth and preceding centuries held before men the idea of a Utopian past and taught the desirability of restoring conditions as they existed centuries ago. It taught that the men of olden times were wiser than we moderns and hence should be followed without question. A surprising amount of such belief still exists. The scientific and the engineering developments of the nineteenth century changed all this and held out to man a hope of a better civilization than has yet existed because these new, yet old, methods of thought and action gave man a greater control over his environment and consequent higher ideals of existence.

Already the results of this new viewpoint is being felt in law, economics, business, and administration, and much progress has been made in these fields in an effort to make them harmonize more closely with the new industrial world. The field of government remains a difficult one in city, state, and nation because we still elect men on the basis of *expediency* and not upon the basis of *knowledge*, but even here we may look for progress. It does not seem possible that a nation intelligent enough to solve the problem of production can fail eventually to solve the coordinate problem of distribution and these are problems that should engage the attention of every educator, especially those of us who are concerned with technical education. For the methods of solution of all of these problems, whether scientific, industrial, or economic, are one and the same and without these methods there can be no progress.

Excerpts from an address delivered at the 37th annual meeting of the S.P.E.E. by its president, Dexter S. Kimball, Dean, College of Engineering, Cornell University, Ithaca, N. Y. The Ohio State University, Columbus, Ohio, June 19–22, 1929.

Load and Stress Cycles in Gear Teeth

By R. V. BAUD[1] and R. E. PETERSON,[2] EAST PITTSBURGH, PA.

When more than one tooth of a gear is in contact, the load is in general not divided equally among the teeth but the actual load division depends on the deflections of the teeth.

A method is derived for computing the load division as a function of position along the arc of action.

Three sets of 10-D.P. gears, all of 1 to 1 ratio, having 20, 35, and 75 teeth, corresponding to contact ratios of 1.68, 2.08, and 2.32 respectively, were studied in this investigation.

The stresses were determined photoelastically because the problem under investigation involves several factors which cannot be determined analytically.

As a result of these tests it may be concluded that increasing the contact ratio produces more favorable load and stress cycles.

IT IS QUITE generally known among gear designers that the number of teeth theoretically in contact may be one, two, three, or more, depending on the position of the teeth along the line of action and also on the design of the gear. Thus, for example, one tooth of a gear may carry the load one-third of the time, and two teeth the remaining two-thirds of the time. However, it must not be inferred that when two teeth of a gear are carrying the load each tooth takes half of the load. The distribution of load depends on the elasticity of the teeth as a function of position along the line of action and also on tip relief and tooth errors. It is the purpose of this paper to present a method of solving the load-division problem analytically, and also to determine by photoelastic tests some general stress relations for gears in which the number of teeth carrying the load varies. Some data bearing on this question have been published,[3] but no results have been available as yet in terms of load distribution and stresses.

A convenient classification of gearing with reference to the problem in hand is in terms of "contact ratio." Such a ratio may be expressed in a number of ways. One expression for "contact ratio" is obtained by dividing the length of the line of action by the normal pitch.[4] Where the line of action is a straight line, which is the case if the tooth contour is a pure involute, the above definition of contact ratio lends itself to analytical solution. Where the line of action is curved, as is more generally the case, it is more convenient to express contact ratio as the arc of action divided by the circular pitch. The following properties of the contact ratio (n) are useful in analyzing gear-tooth action.

For $n = 1$, one tooth carries load all of the time.

$$2 > n > 1, \begin{cases} \text{one tooth carries load } \left(\dfrac{2}{n} - 1\right) \text{ of the time} \\ \text{two teeth carry load } \left(2 - \dfrac{2}{n}\right) \text{ of the time.} \end{cases}$$

$n = 2$, two teeth carry load all of the time.

$$3 > n > 2 \begin{cases} \text{two teeth carry load } 2\left(\dfrac{3}{n} - 1\right) \text{ of the time} \\ \text{three teeth carry load } 3\left(1 - \dfrac{2}{n}\right) \text{ of the time.} \end{cases}$$

The data of this investigation were obtained from three sets of 10-D.P. gears of 1-to-1 ratio, having 20, 35, and 75 teeth, corresponding to contact ratios of 1.68, 2.08, and 2.32, respectively.

Thus for $n = 1.68$ (see Fig. 6), one tooth carries the full load 0.19 of the time and two teeth carry the load the remaining 0.81 of the time. For $n = 2.32$, two teeth carry the load 0.59 of the time, and three teeth the remaining 0.41 of the time.

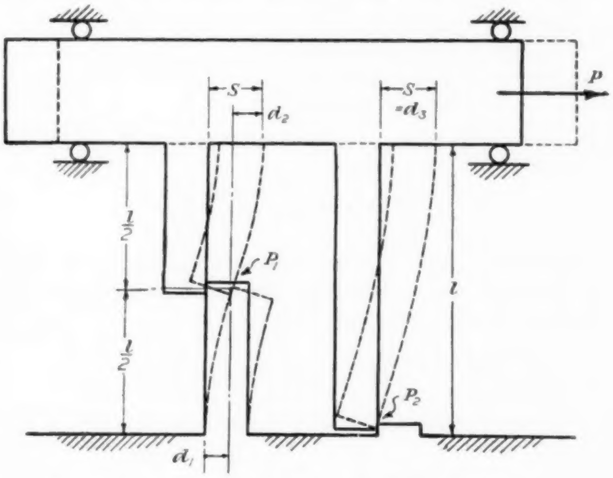


Fig. 1 Illustrative Example of Beam Deflection

It is assumed in the above relations that the teeth have perfect involute contours. The effect of tip relief and spacing errors modifies the above results slightly.

Analytical Solution of Load Division

It was stated at the beginning of the paper that when two teeth of a gear are carrying the load, the division of the load is not necessarily such that each tooth takes half of the load. To make this clear, a simple case, using rectangular beams, will now be given, it being understood that such a presentation must be considered merely as an illustration and that the quantitative results are not to be applied to the problem of gear teeth. Consider two pairs of rectangular cantilever beams such as shown in Fig. 1. Let the load on the left pair be denoted by P_1 and the load on the right pair by P_2. The total load P is equal to $P_1 + P_2$. The beams will deflect as shown in Fig. 1 so that

$$S = d_1 + d_2 = d_3$$

For cantilever beams,

$$d_1 = d_2 = \frac{P_1\left(\dfrac{l}{2}\right)^3}{3EI} \qquad d_3 = \frac{P_2 l^3}{3EI}$$

$$P_1 = 4P_2 \qquad P_1 = \frac{4P}{5}$$

[1] Research Laboratory, Westinghouse Elec. & Mfg. Co.

[2] Research Laboratory, Westinghouse Elec. & Mfg. Co. Assoc-Mem. A.S.M.E.

[3] "Influence of Elasticity on Gear-Tooth Loads," Mechanical Engineering, vol. 49, no. 6, p. 644.

[4] "Number of Teeth in Contact," A. B. Cox, *American Machinist*, Nov. 11, 1920. See also Buckingham, "Spur Gears," p. 37–40.

Presented at the Thirteenth Annual Convention of the American Gear Manufacturers Association, Cleveland, Ohio, May 16 to 18, 1929.

Thus it is seen that for the proportions shown in Fig. 1, corresponding roughly to pitch-point and engagement positions of gear teeth, the left pair takes not half of the load but four-fifths, because of the elasticity of the beams in bending.

The division of load in gear teeth is not as simple as in the case just given, but the general ideas are similar. In the first place, it will be assumed that the gear teeth are perfect involute teeth and are being rotated together very slowly (no dynamic effects).

When load is applied to gear teeth, deformation arises from two causes: First, there is a local compression as the line of contact broadens into a thin rectangular area. Such a deformation in gear teeth is analogous to compressing two cylinders having radii equal to the radius of the gear teeth at the point of contact. The deflection in the case of two cylinders is given by Föppl[5] as

$$d_1 = 2\left(\frac{1-\nu^2}{E}\right)\frac{P}{\pi}\left(\frac{2}{3} + \log\frac{4r_1}{b} + \log\frac{4r_2}{b}\right) \ldots\ldots [1]$$

where ν = Poisson's ratio
E = modulus of elasticity
r_1, r_2 = radii of cylinders
b = width of flattened area.

The width of the flattened area b is found from the Herz equation[6]

$$b = 3.04\sqrt{\frac{P}{E}\frac{r_1 r_2}{(r_1 + r_2)}} \ldots\ldots\ldots\ldots [2]$$

The second type of deformation is a bending of the tooth as a whole. This is found by considering the deflection of a cantilever beam of trapezoidal form:[7]

$$d = \frac{12Pl^3}{Eh_0^3}\left[\left(\frac{3}{2} - \frac{a}{2l}\right)\left(\frac{a}{l} - 1\right) + \log\frac{l}{a}\right] + \frac{4P(l-a)(1-\nu)}{(h-h_0)E} \ldots\ldots [3]$$

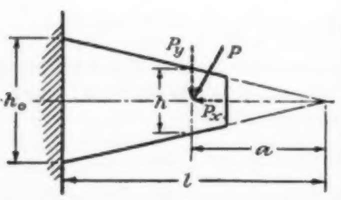


FIG. 2 TRAPEZOIDAL CANTILEVER BEAM NOTATION

in which the notations are as shown in Fig. 2.

The expression within the brackets of [3] is rather difficult to evaluate for large values of a, so a curve of this expression as a function of l/a is given in Fig. 3.

In some cases the tooth is better approximated by a rectangular beam, in which case the deflection becomes

$$d_2 = \frac{Pl^3}{3EI} + \frac{2Pl(1-\nu)}{Eh} \ldots\ldots\ldots\ldots [4]$$

It is assumed that the part of a gear inside the root circle is a rigid body, so that deformations occur in the teeth only. Therefore, if the *pinion* is held stationary and the gear allowed to rotate due to deformations of the teeth, the base of each *gear* tooth will advance the same amount along the root circle. This corresponds to a definite angular movement of the gear, and therefore to a definite length of the arc at the pitch radius of the gear. The following relation is therefore taken as a basis of this analysis:

$$S = d_g + d_p + c = d_g' + d_p' + c' = d_g'' + d_p'' + c'' \ldots [5]$$

where d_g = bending deflection of gear tooth referred to pitch line of gear
d_p = bending deflection of pinion tooth referred to pitch line of gear
c = compression deflection of teeth referred to pitch line of gear.

The above notations have reference to a particular pair in contact, the prime notations to a second pair in contact, and the second notations to a third pair in contact, as the case may be.

The manner in which the deflections are referred to the pitch

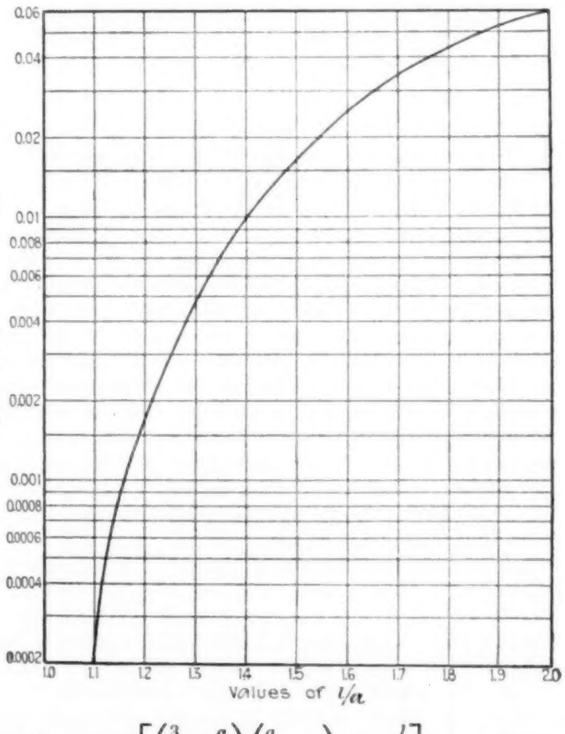


FIG. 3 VALUES OF $\left[\left(\frac{3}{2} - \frac{a}{2l}\right)\left(\frac{a}{l} - 1\right) + \log\frac{l}{a}\right]$ AS A FUNCTION OF $\frac{l}{a}$

line of the gear may be obtained by considering the trigonometry of Fig. 4.

$$d_g = (d_2)_g\,(\cos\alpha_g)\left(\frac{r_p}{r_b}\right) \ldots\ldots\ldots\ldots [6]$$

$$d_p = (d_2)_p\,(\cos\alpha_p)\left(\frac{y_2}{y_1}\right)(\cos\beta)\left(\frac{r_p}{r_c}\right) \ldots\ldots [7]$$

$$c = d_1\,(\cos\beta)\left(\frac{r_p}{r_c}\right) \ldots\ldots\ldots\ldots [8]$$

where d_1 and d_2 are deflections determined by Equations [1] and [3].

The elasticity of the teeth in any particular position may be represented by a factor k, defined as the total deflection of a pair of teeth in contact (referred to the pitch line) per unit load per inch of face. Elasticity factors, as a function of position

[5] Föppl, "Vorlesungen über Technische Mechanik," vol. 5, 4th ed., p. 346.
[6] Timoshenko and Lessells, "Applied Elasticity," p. 24.
[7] Timoshenko and Baud, "Strength of Gear Teeth," MECHANICAL ENGINEERING, vol. 48, no. 11, p. 1108.

along the arc of action, are shown in Fig. 5 for the three gear sets which were studied. Since the total deflection is practically a linear relation with respect to load, the elasticity factor k is similar to a spring constant for any given position along the line of action, the total deflection (referred to the pitch line) being of the form kP. Thus the fundamental assumption of

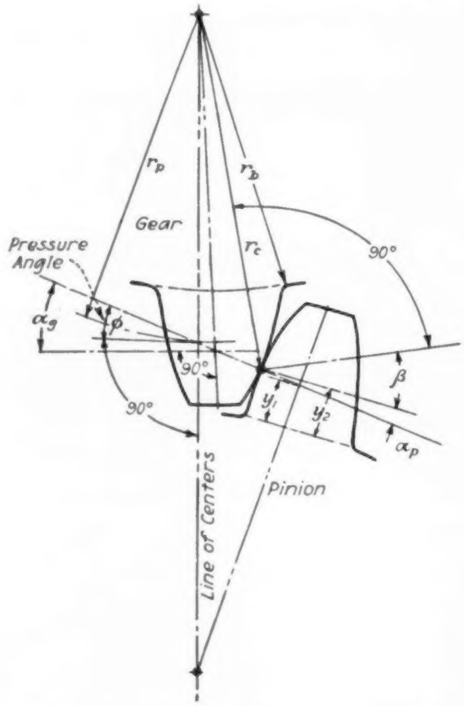


FIG. 4 DEFLECTION REFERENCE NOTATIONS

Equation [5] may be expressed as follows for two pairs of teeth in contact:

$$S = k_1P_1 = k_2P_2$$

where k_1 and k_2 = elasticity factors (Fig. 5) and
P_1 and P_2 = loads carried by the two pairs in contact.

$$\frac{P_1}{P_2} = \frac{k_2}{k_1}$$

By proportion by addition

$$\frac{P_1}{P_1 + P_2} = \frac{k_2}{k_1 + k_2}$$

Similarly

$$f_1 = \frac{k_2}{k_1 + k_2} \qquad [9]$$

$$f_2 = \frac{k_1}{k_1 + k_2} \qquad [10]$$

where f_1 = fraction of load carried by the first pair of teeth and f_2 the fraction carried by the second pair. Obviously, $f_1 + f_2 = 1$.

For three pairs in contact,

$$S = k_1P_1 = k_2P_2 = k_3P_3$$

and

$$\frac{P_3}{P_2} = \frac{k_2}{k_3}$$

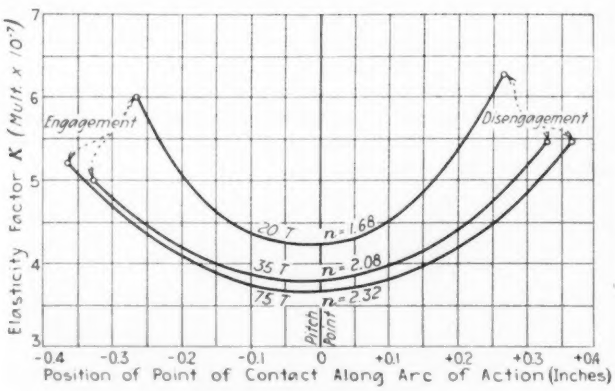


FIG. 5 ELASTICITY FACTORS FOR 10-D.P. GEAR TEETH OF 1:1 RATIO

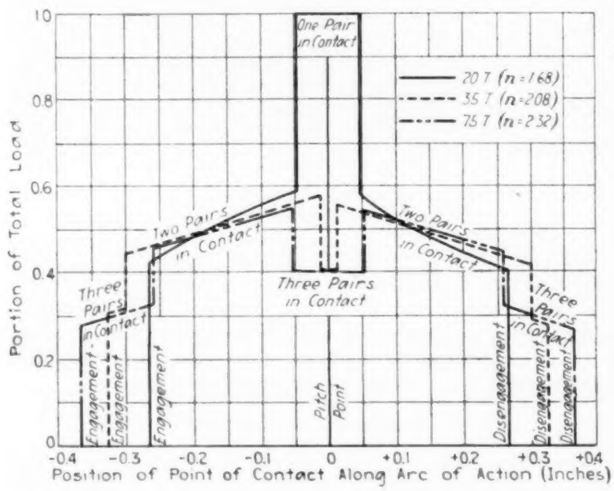


FIG. 6 LOAD-DIVISION CURVES (THEORETICAL)

By proportion by addition,

$$\frac{P_3}{P_2 + P_3} = \frac{k_2}{k_2 + k_3}$$

Also

$$\frac{P_3}{P_1} = \frac{k_1}{k_3}$$

Substituting,

$$\frac{P_1}{P_2 + P_3} = \frac{k_2k_3}{k_1k_2 + k_1k_3}$$

By proportion by addition,

$$\frac{P_1}{P_1 + P_2 + P_3} = \frac{k_2k_3}{k_1k_2 + k_2k_3 + k_1k_3}$$

and

$$f_1 = \frac{k_2k_3}{k_1k_2 + k_2k_3 + k_1k_3} \qquad [11]$$

Similarly

$$f_2 = \frac{k_1k_3}{k_1k_2 + k_2k_3 + k_1k_3} \qquad [12]$$

$$f_3 = \frac{k_1k_2}{k_1k_2 + k_2k_3 + k_1k_3} \qquad [13]$$

where f_1, f_2, f_3 = fraction of load carried by the first, second, and third pairs of teeth, respectively. As before, $f_1 + f_2 + f_3 = 1$.

Using the above equations, the load-division curves of Fig. 6 were obtained for the three gear sets in question. It is again emphasized that these results are for perfect involute contours. The effects of tip relief and spacing errors have been investigated and will be published subsequently.

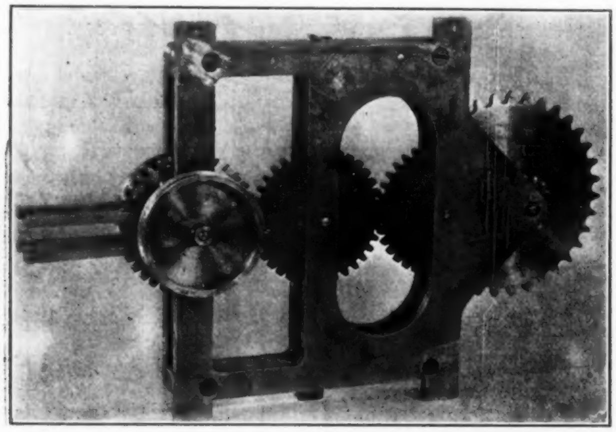


FIG. 7 STEEL FRAME WITH TWO 10-D.P. CELLULOID GEARS OF 35 TEETH EACH

From the loads given by these curves it is possible to make computations of the stresses by use of the flexure formula. Since such a procedure involves an unknown stress-concentration factor due to curvature at the fillet, as well as a further unknown factor due to the penetration effect of the load, it was considered advisable to investigate stress phenomena photoelastically.

PHOTOELASTIC TESTS

General Remarks. So far, an analytical method is given which will enable the gear designer to compute the load cycle for multiple contact. The knowledge of this load cycle is important since at present, when considering the wear of the teeth, the gears are designed on a basis of limiting loads rather than limiting contact stresses. Furthermore a knowledge of the magnitude of the load is required for the analysis of impact and vibration, i.e., for the analysis of noise, and also for the approximate computation of the magnitude of stress in various points of the gear tooth.

However, there are various difficulties in computing gear-stresses, such as, for instance, stress concentration at the contact point and in the fillets, etc. Recourse is therefore made to experiments, notably to such with polarized light, employing transparent models.[8] Such experiments have been made in our case with the three sets of gears mentioned in the introduction. The scope of these experiments was to show the effect of contact ratio on the magnitude of stresses. These experiments were carried out as follows:

At first the rotating gears were inserted in the polarizing instrument and conclusions were drawn by inspecting the color fringes. Motion pictures were then made (see Appendix No. 2). Later on it was decided to make actual stress readings. Since a considerable time had elapsed between the machining of the models and the actual testing, some initial stresses were produced at certain spots, such as, for instance, at the fillet edges. The stress readings were therefore not made at these edges, but below the edges, namely, at points M and N, see Fig. 10b, which points were found to be quite free from initial stress.[9] Since the points M and N are only a little below the fillet edge it can be assumed that the variation of the stress in these points is similar to the variation of the maximum fillet stress.

The stress readings were made by stressing a simple tensile-test specimen to a magnitude such as to produce a color similar to that observed in the points M and N. This method is not quite as accurate as the compensation method, but has an

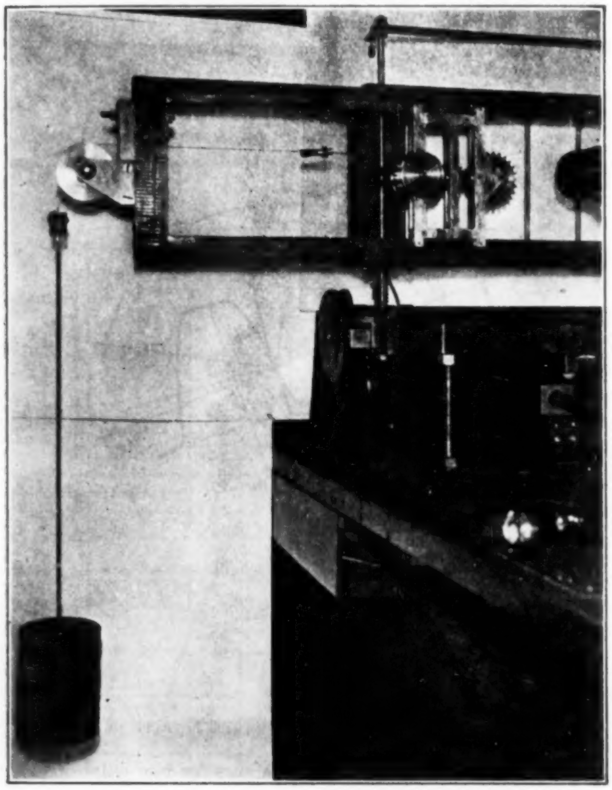


FIG. 8 LOADING ARRANGEMENT FOR STATIC TESTS
(Steel frame with two 10-D.P. celluloid gears, 20 teeth each.)

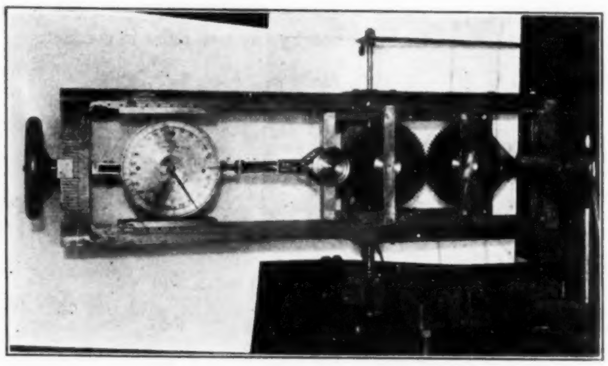


FIG. 9 LOADING ARRANGEMENT USED FOR STUDY OF CONTINUOUS ROTATION (MOVING PICTURES)
(Steel frame with two 10-D.P. celluloid gears, 75 teeth each.)

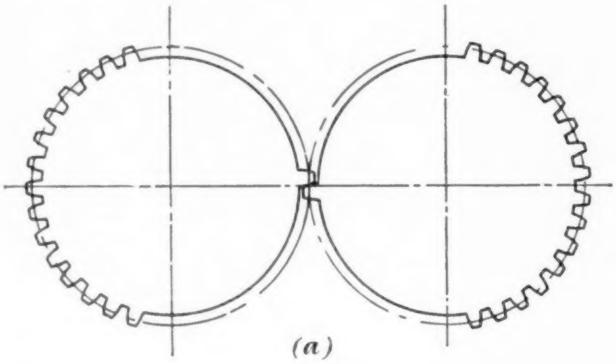
[8] R. V. Baud, "Study of Stresses by Means of Polarized Light and Transparencies," *Proc. Eng. Soc. W. Pa.*, vol. 44, no. 6, July, 1928.

[9] Since the stress readings were made not at the surface but below it, they do not represent one principal stress but the difference $p - q$ between the two principal stresses p and q. Since $(p - q)/2$ is the maximum shear stress, the readings actually represent twice the maximum shear stress in points M and N.

advantage in that the stress directions are not required when the readings are taken. In order that the initial stresses should be small as compared with those produced by loads, comparatively large torques were applied and the gear tooth was stressed in certain portions beyond the proportional limit of this material, something which the authors otherwise always carefully try to prevent in their photoelastic experiments, if possible. For the above reasons they do not claim a high degree of accuracy for these particular tests. They are sufficiently accurate, however, for the purpose for which they were made.

Description of Models and Arrangements for Tests. Three sets of 10-D.P. gears, all of 1-to-1 ratio, and having, respectively, 20, 35, and 75 teeth, were made of camphor celluloid of 0.2385 in. thickness. They were so designed as to give approximately the contact ratios 1.75, 2.00, and 2.25, which ratios will later on be called the nominal contact ratio n_n. From trigonometrical computation, the theoretical ratios n were found to be 1.68, 2.08, and 2.32 for the three sets. For each set a steel frame was made, as shown in Figs. 7, 8, and 9. These frames were so designed that they could be inserted in the testing equipment and load could be applied either directly by weights (Fig. 8) or by a friction arrangement (Fig. 9). The friction arrangement was used when a continuous rotation was desired, whereas the direct-weight arrangement was used in the actual testing.

In addition to the three steel frames, a further frame was made and two gears were inserted which nominally had 35 teeth each but which actually had half of the teeth removed on one side with the exception of one tooth as shown in Fig. 10*a*.



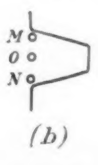


FIG. 10 (*a*) 10-D.P. CELLULOID GEARS, HAVING NORMALLY 35 TEETH, USED FOR SINGLE-TOOTH TEST. (*b*) GEAR TOOTH SHOWING POINTS M AND N AT WHICH STRESS READINGS WERE MADE (OM = ON = 0.8 ÷ D.P.)

Description of Experiments. With these four gear sets, the following two tests were made:

1 Contact was secured and maintained at the pitch point P, and various torques applied.

2 Contact was made first at the tip and then at successive points along the flank until the gears disengaged, the torque being maintained constant.

In the first experiment it was observed that the contact ratio changed with the load. For instance, when a certain load on the 20-tooth gear set was exceeded, there were three pairs of teeth in contact instead of only one. Furthermore, in the second experiment it was observed that at engagement the contact remained at the tip of the tooth of the driven gear during rotation through a small angle; the contact point then moved toward the root and then reversed its direction and moved backward toward the pitch point. By connecting the loci of all contact points from engagement to disengagement, it was found that the line of action consisted of a straight part, AB, and two arcs, XA and BY, which are parts of the addendum circles of the two gear arcs, as shown in Fig. 11. This extension of the line of action is due to the large deflection of the celluloid teeth, which produces a premature engagement and a delayed disengagement, i.e., the extensions XA and BY of the line of action.

It should be noted that for flexible materials such as, for instance, micarta, these extensions have some practical importance. It is evident, however, that for ferrous materials the extensions XA and BY are very small and can be neglected.

So far, a definition of theoretical and nominal contact ratio was given and denoted by n and n_n, respectively. In the interpretation of photoelastic results a further expression for contact ratio was taken to be the total line XY divided by the normal pitch. This was called the "actual contact ratio" and denoted by n_a.

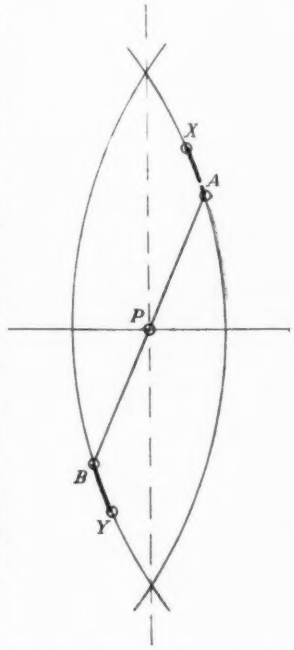


FIG. 11 TYPICAL LINE OF ACTION OBTAINED FOR TESTS WITH CELLULOID GEARS

Results Obtained From Tests. First Experiment. In Figs. 12 and 13 are plotted the stresses in pounds per square inch against the applied loads per inch of face. For a few loads the actual contact ratios n_a were established, and the information obtained is given along the curves of Figs. 12 and 13.

From this it is seen that it was possible in the case of celluloid gears to increase the contact ratio by increasing the load on the gears.

Second Experiment. In Figs. 14 to 17 are plotted the stresses in pounds per square inch of face against the full length XY of the line of action. The magnitude of the stresses is not given for the loads actually used in the experiments, but was changed to a load of 100 lb. per inch of face. The following example will illustrate the basis on which the data of Figs. 14 to 17 are given. In order to obtain an actual contact ratio of 2.25 with the gear having a nominal contact ratio of 2, a load of 44.6 lb. had to be applied for the 0.2385-in. thick models and the stress s in one of the points M or N was obtained. The equivalent load for 1 in. of face is obtained by multiplying by 1/0.2385 = 4.19. The load per inch of face in the case referred to above becomes 4.19 × 45 = 187 lb. In order to obtain a comparative basis for all curves, the stress s was then reduced to correspond to that due to a load of 100 lb. by using in this case the divisor 1.87.

On curves in Figs. 14 to 17 are also given the lengths XA and BY of premature engagement and delayed disengagement. For instance, $AX_{2\cdot25}$ is the length of the arc on the addendum circle of the driven gear which indicates the amount of premature contact. The normal pitch p_n is also given on the drawings. According to definition, we have in our case

$$n_n = \frac{AB}{p_n} = 2$$

$$n_a = \frac{X_{2.25}\,Y_{2.25}}{p_n} = 2.25$$

Discussion of Results. First Experiment. In order to explain the results of this experiment, Figs. 18 to 20 were constructed.

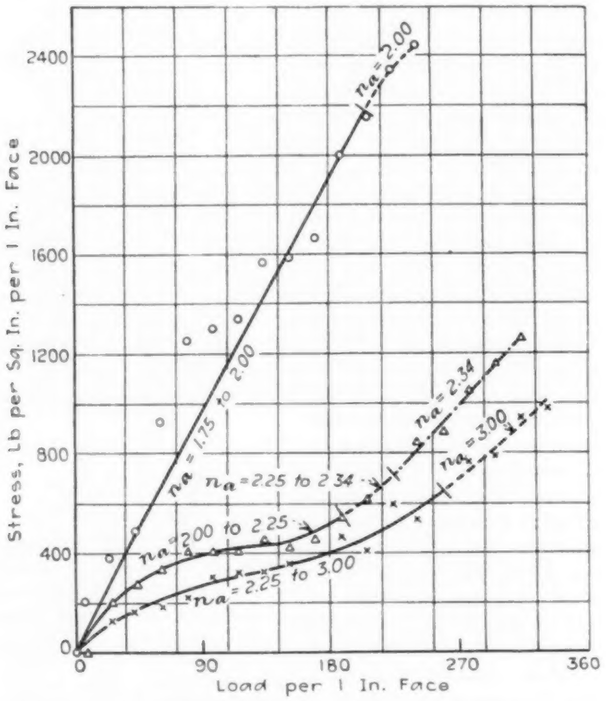


FIG. 12 LOAD-STRESS DIAGRAM FOR POINT M, FIG. 10 (b)

In these figures the middle pair make contact at the pitch point P.

For a gear of contact ratio 1.75 and with the contact at the pitch point, there is only one pair of teeth in contact, Fig. 18 (a). For this reason the stresses in point M and N increase linearly with the applied load, which is verified by the experiment. However, when the load of 205 lb. is passed the stresses do not increase proportionally. For loads larger than 205 lb. three pairs of teeth make contact, Fig. 18 (b), thus dividing the load.

Fig. 19 (a) represents the condition of a gear having a nominal contact ratio 2.0. With an increase in the total load applied, the load divides within three pairs of teeth from the very beginning, Fig. 19 (b). Consequently the stress curve will be lower than the stress curve obtained in the case where only one pair of teeth is in contact.

An even lower stress curve is obtained in the case the test is made with the gear having a nominal contact ratio 2, Fig. 20 (a). The difference must be attributed to the fact that the forces at 1 and 2 act nearer the middle of the teeth, see Fig. 20 (b), as compared with the case of the gear with the ratio $n_n = 2$, where the forces are applied at the extremities of the gear teeth and where the teeth do not take much of the total load on account of large deflection encountered, Fig. 19 (b).

It will be noted from the straight-line stress curves of Figs. 12 and 13 that with increasing loads applied at the pitch point the stress at point N increases more rapidly than at point M, which proves that the stress condition in the two fillets is not the same. This is again brought out by the results of the single-tooth test.

Second Experiment. The single-tooth curve for the tension side gives a fairly constant stress which for the whole cycle is smaller than the one on the compression side. This confirms the above statement and a previous photoelastic test made on gears, from which it was also concluded that the maximum fillet stress on the compression side is larger than the one on the tension side.[10] However, the shape of the single-tooth stress curves cannot be readily explained, and since these curves are of considerable importance, it is contemplated to repeat this experiment with improved test conditions, in which we shall have larger teeth without initial stresses and in which we contemplate using the compensation method and applying only torque of such magnitude that the stresses will be within the proportional limit of the material. It is evident that when more than one pair transmits the applied torque, the load is divided and the stresses decrease. Figs. 14 to 17 show convincingly that for the same size gear tooth the *stress curves flatten out with increasing contact ratio.*

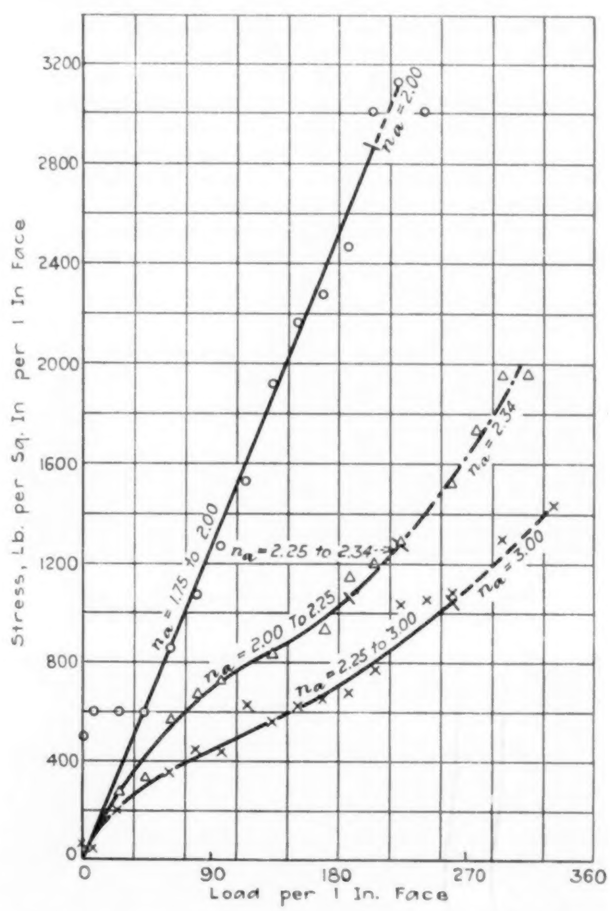


FIG. 13 LOAD-STRESS DIAGRAM FOR POINT N, FIG. 10 (b)

CONCLUSIONS

1 When more than one tooth of a gear is in contact, the load is in general not divided equally among the teeth but the actual load division depends on the deflections of the teeth.

2 Increasing the contact ratio produces more favorable load and stress cycles.

[10] Loc. cit., "Study of Stresses by Means of Polarized Light and Transparencies," p. 215.

ACKNOWLEDGMENT

The authors wish to acknowledge the assistance of Messrs. K. C. Ripley and E. A. Tulus in the computation of data, and of Mr. P. E. Kyle in the photoelastic tests. Further acknowledgment is due Messrs. W. H. Himes and A. Paulsen for their interest and suggestions concerning the investigation. They particularly wish to express their appreciation to Messrs. S. M. Kintner and J. M. Lessells for including work of this type in the research program of the Westinghouse organization.

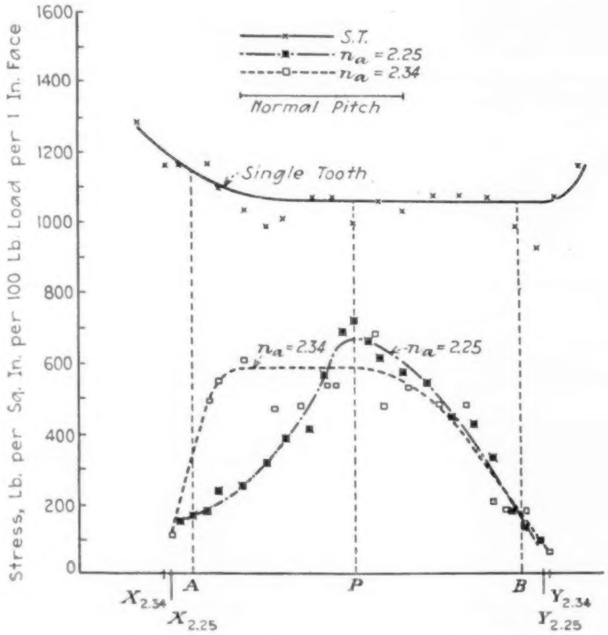


FIG. 14 VARIATION IN THE MAGNITUDE OF STRESS OF POINT M FOR VARIOUS POINTS OF LOAD APPLICATION FOR SINGLE TOOTH AND n_a = 2.25 AND 2.34

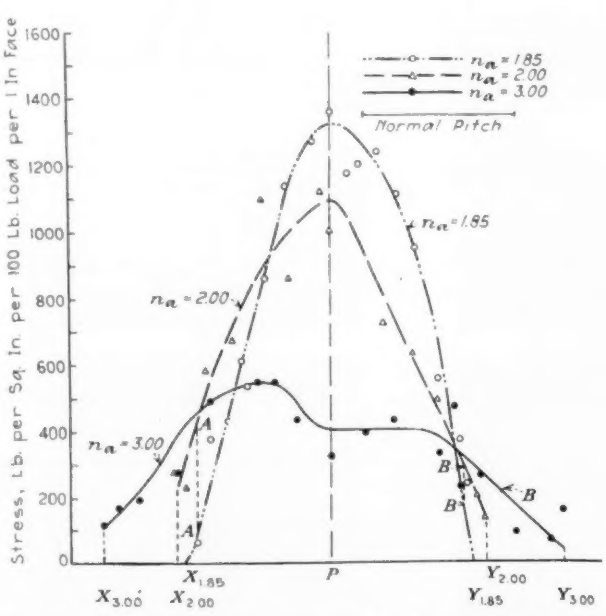


FIG. 15 VARIATION IN THE MAGNITUDE OF STRESS OF POINT M FOR VARIOUS POINTS OF LOAD APPLICATION FOR n_a = 1.85, 2.00, AND 3.00

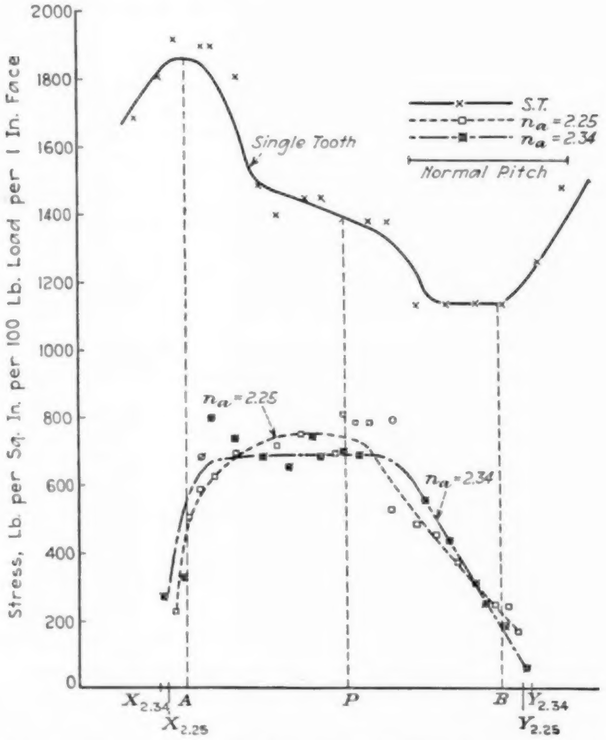


FIG. 16 VARIATION IN THE MAGNITUDE OF STRESS OF POINT N FOR VARIOUS POINTS OF LOAD APPLICATION FOR SINGLE TOOTH AND n_a = 2.25 AND 2.34

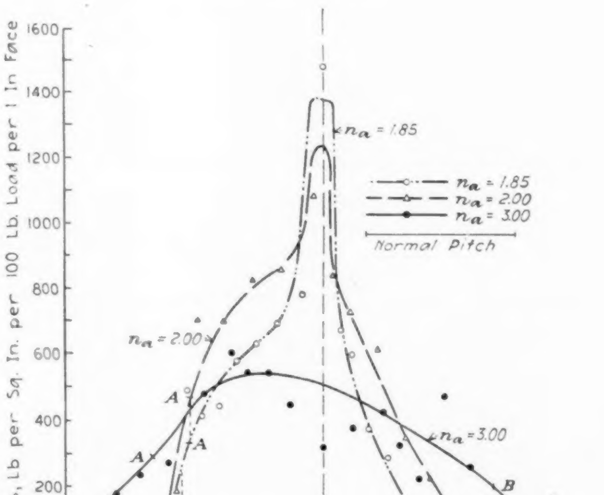


FIG. 17 VARIATION IN THE MAGNITUDE OF STRESS OF POINT N FOR VARIOUS POINTS OF LOAD APPLICATION FOR n_a = 1.85, 2.00, AND 3.00

Appendix No. 1

IT HAS been mentioned in the paper that there exist various difficulties in computing gear stresses, even if the load cycle is known. An unknown factor K has to be added to the flexure formula, which factor, however, can be established from photo-

elastic tests. For instance, to obtain the maximum fillet stress, stress concentration must be considered. The factor K for stress concentration in the fillet has been established for slender teeth and various-size fillets, and an equation has been given.[11] It is herein assumed, however, that the load acts at the tip of the tooth. For stub teeth and also for slender teeth with the load near the fillet, the equation previously given may not be accurate enough.

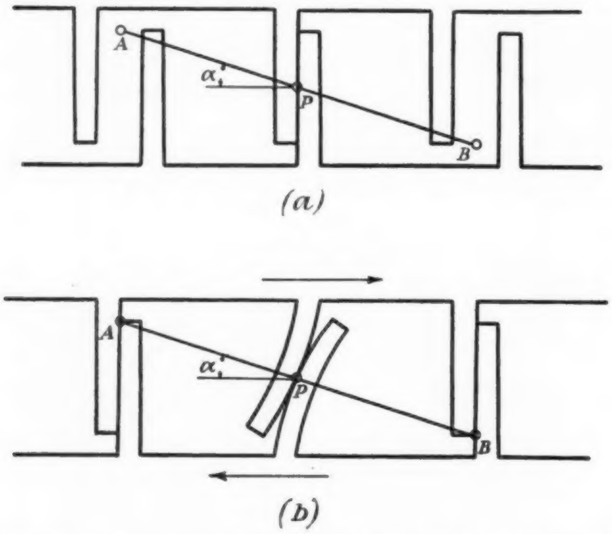


FIG. 18 (a) SCHEMATIC DIAGRAM OF GEARS HAVING A CONSTANT RATIO $n_n < 2$. (b) SAME AS (a) BUT SHOWING EFFECT OF ELASTICITY ON CONTACT RATIO, $n_n = 2$

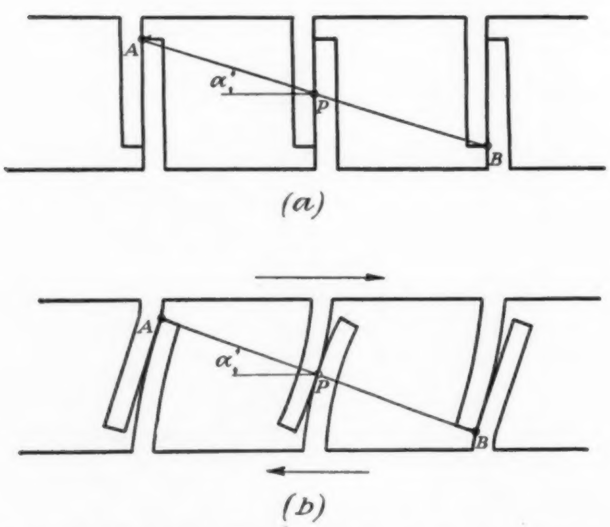


FIG. 19 (a) SCHEMATIC DIAGRAM OF GEARS HAVING A CONTACT RATIO $n_n = 2$. (b) SAME AS (a) BUT SHOWING TOOTH DEFLECTION

Without the knowledge of the factor K it is therefore not possible to compute the stresses accurately. On the other hand, it will now be shown that when the stress cycles for single and multiple contact are given, as in our case, the load cycle can be computed from this.

In Figs. 14 to 17 the stresses are all given for 100 lb. per inch of face. For a certain point of the line of action the stress in one of the teeth with multiple contact will be p_m and the one with the single contact p_s. The loads are acting in proportion to the stress and therefore the load on the tooth will be

$$L_n = \frac{p_m}{p_s} \times 100$$

If n pairs are in contact at the same time, then

$$L_1 + L_2 + \ldots L_n = 100 \text{ lb.}$$

We can compute in this manner L_n from the stress at point M and also from the one at point N, which of course should give the same result. In actually carrying this through, a difference will be found and the mean average can be taken.

Sample Calculation for $n_n = 2.25$ for Points A, B, and P, Fig. 16. From Fig. 16 we obtain the following stresses and loads:

Point	Single tooth	Multiple contact	Loads
A	1860	470	$470 \times 100/1860 = 25$
P	1390	740	$740 \times 100/1390 = 53$
B	1130	230	$230 \times 100/1130 = 20$
			$L_A + L_P + L_B = 98$

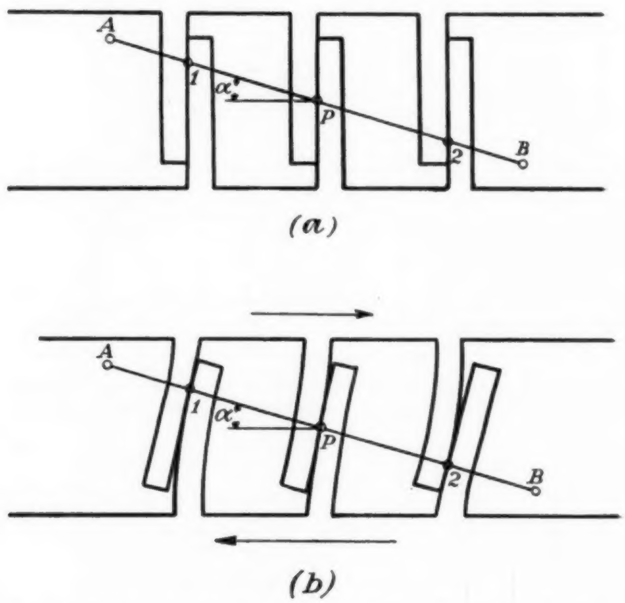


FIG. 20 (a) SCHEMATIC DIAGRAM OF GEARS HAVING A CONTACT RATIO $n_n = 2.25$. (b) SAME AS (a) BUT SHOWING TOOTH DEFLECTION

The sum of these loads should be 100, instead of 98 and we can correct by a factor 100/98, which results in

$$\begin{aligned} L_A &= 25.5 \\ L_P &= 54.1 \\ L_B &= 20.4 \\ \hline L_A + L_P + L_B &= 100.0 \end{aligned}$$

The same procedure was followed for the M point and the following loads were obtained:

$$\begin{aligned} L_A &= 13.8 \\ L_P &= 62.5 \\ L_B &= 23.7 \\ \hline L_A + L_P + L_B &= 100.0 \end{aligned}$$

By taking the mean average and by carrying the same procedure through for points equally spaced along the line of action, the

[11] Loc. cit., "Strength of Gear Teeth," p. 1107.

A B C

Fig. 21 Sections of Motion-Picture Films of Running Gears

curve given in Fig. 22 was obtained, and in a similar manner also the corresponding curve for a contact ratio $n_a = 2.34$.

The check is quite satisfactory, if the large number of variables and the accuracy of the method employed are considered.

Appendix No. 2

VARIOUS motion pictures, 35-mm. standard film, were made of the rotating gears of which the specifications are given in the paper. The peripheral speed in all cases was 8 in. per min.; the load on the scale was 50 lb. in one set of films and 100 lb. in another set. The corresponding loads per inch of face and nominal and actual contact ratios are given in Table 1.

TABLE 1

Film	Load on scale, lb.	Load per inch of face, lb.	n_n	n_a
I	50	102.5	$1^3/_4$	1.8
II	50	102.5	$2^1/_4$	2.4
III	100	205	$1^3/_4$	2.0
IV	100	205	2	2.3
V	100	205	$2^1/_4$	2.6

Since reproduction of the motion pictures was contemplated, ordinary black-and-white films having an orthochromatic emulsion were used instead of color film. This has a disadvantage, however, in that black does not represent the same stress; neither does gray nor white, whereas in the color picture black represents exclusively portions where the shear stress is zero. This statement becomes clear when Table 2 is consulted.

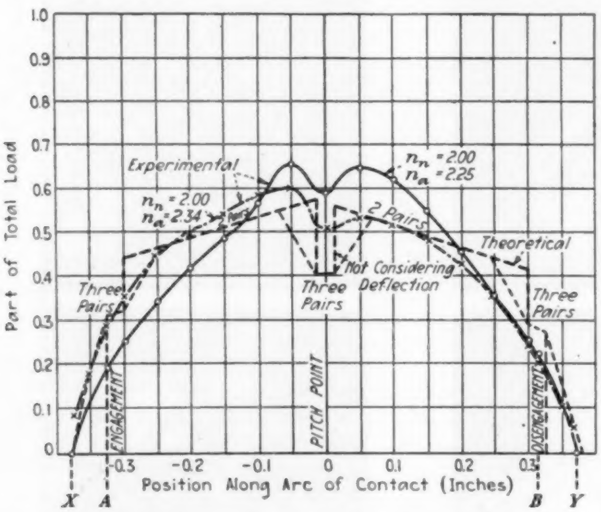


FIG. 22 LOAD-DIVISION CURVES (THEORETICAL AND EXPERIMENTAL)

Fig. 23 represents a photograph taken with an Eastman Kodak double-coated ortho plate.[12] In this figure we find bands of uniform darkness and brightness. For each of these dark bands a number is given. Table 2 can now be used as a key to obtain the approximate magnitude of the shear stress. It will be noted that we have a considerable concentration in the fillet and an excess stress at the point of contact.

It seems obvious that a contact ratio less than 2 is not favorable. A, B, and C, of Fig. 21 are taken respectively from the films III, IV, and V, in order to demonstrate that a contact ratio larger than 2 is more favorable than a ratio close to 2. In evaluating the stress from the black-and-white picture it is suggested that a start be made from a portion of the gear where the stress is zero, then going through the successive changes of black and white as indicated in Fig. 23. To have a decided change in the picture, selections were made at large intervals.

[12] This was to our knowledge the closest approximation of the emulsion of the film. The black and white shades given in Table 2 correspond to the plate but may differ from the film, in case the emulsions had a substantial difference between them regarding color sensitivity.

FIG. 23 PHOTOGRAPH SHOWING STRESS DISTRIBUTION

TABLE 2 COLOR SCALE FOR FIG. 23

Order	Color	Black and white shades as on D. C. ortho plates	Band no., see Fig. 23	Stress or stress diff. $(p - q)$ in lb. per sq. in.
I	Black	Black	0	0
	Olive-gray	Gray	–	0–330
	Yellow-orange	White	–	330–940
	Red-brown	Gray	–	940–1320
	Dark green	Black	1	1320–1530
	Light green	Gray	–	1530–1730
II	Yellow-orange	White	–	1730–2100
	Red-brown	Gray	–	2100–2530
	Green	Black	2	2530–3000
III	Yellow-orange	White	–	3000–3200
	Red-brown	Gray	–	3200–3660
	Green	Black	3	3660–4000
IV	Yellow-orange	White	–	4000–4200
	Red-brown	Gray	–	4200–4500
	Green	Black	4	4500–5100

NUMEROUS attempts have been made to devise a satisfactory variable-speed gear consisting of a group of gear wheels, tapering in diameter, mounted on one shaft, and a single wheel or pinion which can be slid along the second shaft into gear with one or other of the wheels on the first. In an elementary form this system of speed changing is to be found in certain lathes produced by some of the Yorkshire machine-tool makers. In this case the two shafts are parallel. The nest of wheels on the one shaft constitutes a stepped cone. A sliding bracket on the second shaft carries a pinion in driving connection with the second shaft and meshing with an idler which is also mounted on the sliding bracket. *The Engineer*, July 19, 1929, vol. 148, no. 3836, p. 72.

The Production and Uses of Helium Gas

Origin and Occurrence of Helium—Quantity Available—Production, Storage, and Transportation—Properties—Special Problems Connected With Use of Helium in Airships—Cost Estimates

By R. R. Bottoms,[1] Louisville, Ky.

HELIUM was first discovered as a terrestrial element in 1895 by Sir William Ramsay while investigating an inert gas given off from the mineral cleveite on boiling it with sulphuric acid. Ramsay thought this gas was argon, but upon examining the spectrum of the gas in a Crookes tube it was found to give a brilliant yellow line. This line had already been discovered in 1868 to exist in the spectrum of the sun and had been ascribed to a new solar element. It was therefore called helium.

Helium belongs to the group of elements known as the rare gases of the atmosphere. The other gases of this group are neon, argon, krypton, and xenon. All are characterized by their comparative rarity, chemical inertness, and the fact that they are monatomic elements.

For about 15 years succeeding Ramsay's discovery of helium in 1895 a great deal of research was carried out on its occurrence and properties. It was found to be a constituent, in small amounts, of the atmosphere, of gases from mineral springs, of volcanic gases, and to occur in minute quantities in sea water, to be present in the atmosphere to the extent of one part in 185,000, and to occur in minute traces in nearly all rocks and minerals.

Occurrence

In 1905, Cady and MacFarlane, of the University of Kansas, investigating a peculiar non-combustible gas from Dexter, Kan., found that it contained 1.84 per cent helium. This discovery led them to examine other gases from the same locality and from other points in Kansas, and in all of them helium was found. These investigations have been greatly extended, and today almost all known deposits of natural gas in the world have been tested for helium.

Only in the United States and Canada, however, are helium-bearing gas deposits found with a sufficient helium content to make it economical to process them.

In Italy, however, there are certain gases issuing with steam from boric acid fumaroles which might possibly be treated for the recovery of helium. These gases, after the condensation of steam, consist principally of carbon dioxide, but since the latter gas is very easily liquefied there would be no great technical difficulty in treating the gas. It has been estimated that from 200,000 to 250,000 cubic feet of helium per day could be obtained from this source.

In Canada there are two gas fields carrying a small percentage of helium—the Bow Island field in Alberta, a few miles north of the Montana line, and a field in Ontario north of Lake Erie. Neither of these fields carries a helium content of over 0.5 per cent. In this country, under present conditions, it would not be considered a commercial grade of helium-bearing gas.

In the United States helium occurs to some extent in most of the natural-gas deposits. However, there are some occurring on the Pacific Coast, on the Gulf Coast in Louisiana, and in the Rocky Mountain Region which show no helium that can be detected by the usual analytical method.

Natural gases from different fields and even from different geological strata in the same field may differ widely in chemical composition and helium content. They fall into four main types: hydrocarbon, nitrogen, carbon dioxide, and sulphur, according as hydrocarbons, nitrogen, CO_2, and H_2S are the most prominent constituents. Typical analyses are given in a table in the complete paper.

Origin of Helium

The facts relating to the origin of helium and the reason for its accumulation in certain natural-gas deposits have not been entirely cleared up. There are several theories relating to the origin of helium: namely,

1 The radioactive theory which assumes that the helium in natural-gas deposits has been accumulated by radioactive disintegration of radium-bearing minerals distributed through the sedimentary rocks.

2 The theory propounded by Rogers that the helium occurring in natural-gas deposits is primordial in origin and has nothing to do with radioactivity. The evidence in either case is so meager that it is practically impossible to determine which of these theories is correct. Rogers objects to the radioactive theory on the basis that the quantity of radioactive elements necessary to produce the enormous volume of deposits would be greatly in excess of what is actually found in the crust of the earth.

The facts relating to the accumulation of helium of course are simple. A great deal of investigation has shown that it occurs in various sedimentary rocks overlying, or at least in the vicinity of, granite uplifts which have been faulted, and we find that along these granite folds the natural gas will usually contain anywhere from $^1/_{10}$ per cent helium up to as high as 8 per cent, while the gas occurring outside of the faulted area is nearly always low in helium content.

A theory evolved by the author is that the original source of helium is the basal crystalline rocks underlying the sedimentary deposits, and that the helium with large amounts of nitrogen and carbon dioxide in the granite seeps into the sedimentary deposits through fissures, crevices, and fractures in the basal rocks and diffuses and migrates through the structural rocks until it is trapped underneath an impervious cap rock in anticlinal folds or domes. Whether the helium in the granite rocks is primordial helium or results from radioactive disintegration of uranium, radium, and thorium, makes little difference.

If this theory is correct, then we should feel more certain of finding helium in the vicinity of major granite uplifts or folds, especially if faulted, and in the vicinity of other volcanic activity which would tend to open up passageways for helium from the interior of the earth.

The helium-bearing gas, accumulating as above described, will probably consist entirely of non-combustible gases, principally nitrogen and carbon dioxide. Unless hydrocarbon gas forms in surrounding source beds and migrates into the same reservoir and dilutes the accumulating volcanic gas, the helium-bearing gas will consist almost solely of nitrogen, carbon dioxide, and helium. If dilution has taken place, of course the helium content of the gas will then depend upon the extent of that dilution.

---

[1] Kentucky Oxygen-Hydrogen Co., Inc.

Presented at the Third National Meeting of the A.S.M.E. Aeronautic Division, St. Louis, Mo., May 27 to 30, 1929. Greatly abridged.

The Helium Company, the latter part of 1928, using this theory as a guide, began some investigations looking toward the discovery of helium in those parts of the country where the necessary geological conditions seemed to be favorable toward the accumulation of helium-bearing gas. Data are being accumulated which will form a valuable guide for intelligent exploration

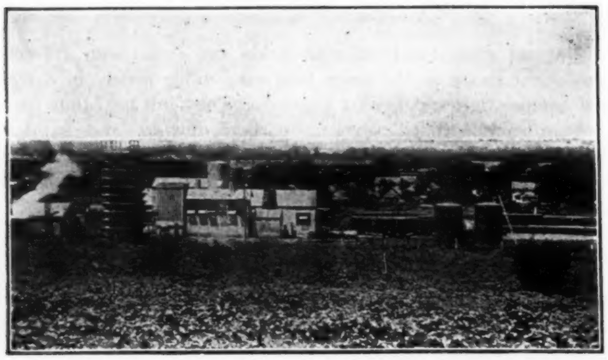


FIG. 1 VIEW OF THE HELIUM COMPANY'S PLANT AT DEXTER, KAN.

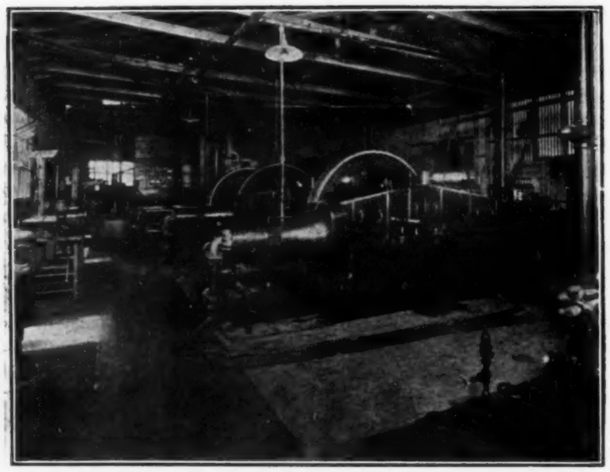


FIG. 2 INTERIOR VIEW OF THE HELIUM COMPANY'S PLANT AT DEXTER, KAN.

and will ultimately give the airship industry the necessary assurance as to the location and extent of its helium supply.

Quantity of Helium Available

There seem to be some misgivings in the minds of those interested in airship development regarding the amount of helium available for airship use. These misgivings are entirely unfounded. A recent estimate of the total available helium already in sight is about as follows:

Kansas	2,000,000,000 cu. ft.
Texas	3,000,000,000 cu. ft.
Colorado	2,000,000,000 cu. ft.
Other states	3,000,000,000 cu. ft.

This gives us a grand total of 10 billion cubic feet of helium, which, if used at the rate of 10 million feet a year, would last for 1000 years, and if used at 10 times that rate would last for 100 years.

Production, Storage, and Transportation

The technical methods of producing helium are based on the fact that all gases, with the exception of helium, can be reduced to the liquid phase at readily acquired temperatures. Helium being a most difficult gas to liquefy and so refractory in this connection that it has been liquefied at only two places in the world, makes it very easy therefore to separate helium from the other constituents with which it is associated by simple liquefaction of the other constituents and the separation of the gaseous helium from the liquids. Every process for the production of helium is based on these facts.

[The complete paper, which will be published in *Aeronautical Engineering* (the Transactions of the A.S.M.E. Aeronautic Division), contains descriptions of (1) the helium plant used until recently by the Government at Fort Worth, Texas, (2) the helium plant now being used by the Government at Amarillo, Texas, and (3) the Helium Company's plant at Dexter, Kansas. These descriptions are extended and depend on schematic drawings which cannot well be reproduced here. Early work in the production of helium from natural gas in the United States was summarized by Geo. A. Orrok, Mem. A.S.M.E., in MECHANICAL ENGINEERING, vol. 41 (1919), p. 155; following which were given

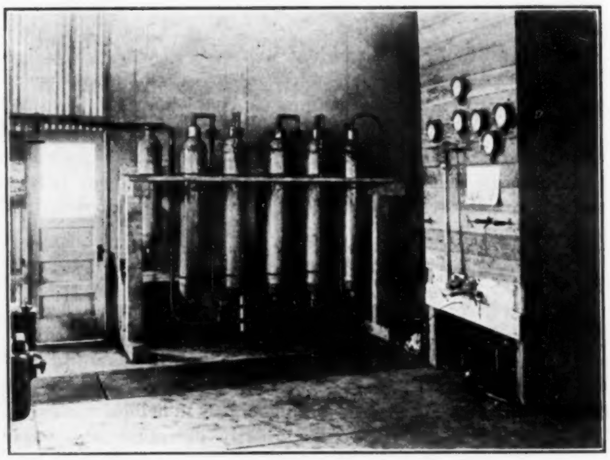


FIG. 3 GAS-DRYING BATTERY AND COLUMN IN DEXTER PLANT

descriptions of the different systems of gas liquefaction and separation.]

At the time of writing (April 17, 1929) only one plant is operating at all—that of the Helium Company at Dexter, Kan. The new plant at Amarillo recently built by the U. S. Bureau of Mines is not yet in operation and it is not known when it will be placed in operation.

Since it is necessary to have large volumes of helium on hand at any major airship-operating station, some kind of storage facilities will have to be provided. There are three general methods of storage:

1 Atmospheric holders or gasometers. A 6,000,000-cu. ft. holder of this type will cost about $1,200,000

2 Storage in medium-pressure tanks, that is, about 60 lb. per sq. in. Tanks of this type having sufficient capacity to hold 6,000,000 cu. ft. would cost erected something like $560,000

3 Storage in high-pressure containers, that is, in containers that will withstand an internal pressure of about 2000 lb. per sq. in. Such storage as this has been provided at the Naval air station at Lakehurst, N. J. The present cost of storage facilities of this kind for a supply of 6,000,000 cu. ft. of helium would be, installed, about $400,000.

It therefore appears that the most economical method of storing helium at an airship depot would be in relatively large-size high-pressure storage tanks. There are three general types of these cylinders:

1 Relatively small cylinders capable of holding about 400 cu. ft. of helium each. These cylinders would be connected up in banks and manifolded with a common valve
2 Medium-size tanks, approximately 4 ft. in diameter by 45 ft. long which are usually buried under the ground. Both of the above types of cylinders are seamless, forged or drawn cylinders
3 The third type is of welded steel, about 10 ft. in diameter by 100 ft. long.

Due to the fact that helium deposits are usually located long distances from operating bases, it is necessary to provide transportation facilities. This is one of the greatest problems in

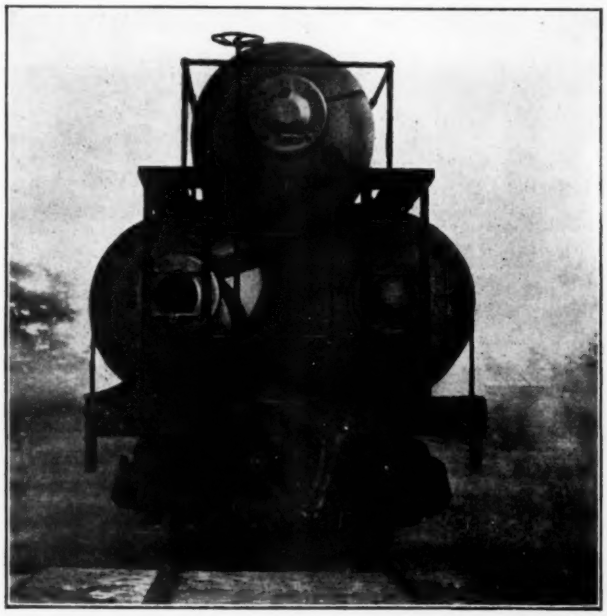


FIG. 4 END VIEW OF NAVY DEPARTMENT'S HELIUM TANK CAR

the use of helium in airships. The usual method has been to employ steel cylinders of approximately $1^1/_2$ cu. ft. dead volume. These cylinders are filled at about 2000 lb. pressure, and at this pressure hold something like 190 cu. ft. of helium. Each cylinder weighs from 125 to 135 lb., and approximately 600 can be loaded into an ordinary box car. The helium content of these cylinders will amount to approximately 100,000 cu. ft. The transportation charges on this amount of helium from the Mid-Continent field to the eastern seaboard will amount to about $12 per M cu. ft. The freight on the empty cylinders returned will increase this to about $18 per M cu. ft.

In their efforts to reduce transportation costs both in freight charges and in handling charges at their terminal, the Navy Department, several years ago, developed a tank car which would transport approximately 200,000 cu. ft. of helium at 2000 lb. pressure. Using such transportation the cost of transporting helium from Dexter to Lakehurst has been reduced to less than $4 per M cu. ft. This tank car, which consists of three cylinders about $4^1/_2$ ft. in diameter by 39 ft. long, costs approximately $60,000. Cars of this character can be purchased almost as cheaply as fixed storage of the same kind.

PROPERTIES OF HELIUM

Helium has several remarkable properties which make it of great interest and which will render it one of the most important of the industrial gases. It is colorless, and odorless, has a mo-

FIG. 5 HIGH-PRSURESE HELIUM STORAGE AT LAKEHURST, N. J., BEFORE COVERING

FIG. 6 DETAIL OF STORAGE PLANT SHOWN IN FIG. 5

lecular weight of 4, and is only slightly heavier than hydrogen, the lightest substance known.

Helium is almost completely inert. It cannot be made to enter into chemical association with any other substance, with the possible exception of mercury and platinum under special conditions. It is not soluble in metals, either liquid or solid, and in consequence may find extensive use in metallurgical operations.

The solubility of helium in water and aqueous solutions is only about half that of nitrogen, but its rate of effusion is more than three times that of nitrogen. For this reason Dr. Elihu Thomson suggested that helium might be used in a mixture with

oxygen as an atmosphere for deep-sea divers and caisson workers. Since that time the Bureau of Mines at Pittsburgh has found that divers can work at a greater depth with greater comfort and with a much shorter decompression period when a helium-oxygen mixture is used instead of air. In other words, helium prevents the development of caisson disease or "bends."

The weight of 1000 cu. ft. of helium, under normal atmospheric conditions, is 11 lb. That of air under the same conditions is about 75 lb. Therefore the buoyant effect or "lift" of helium is 65 lb. per 1000 cu. ft. The two new ships recently contracted for by the Navy Department will have a capacity of 6,500,000

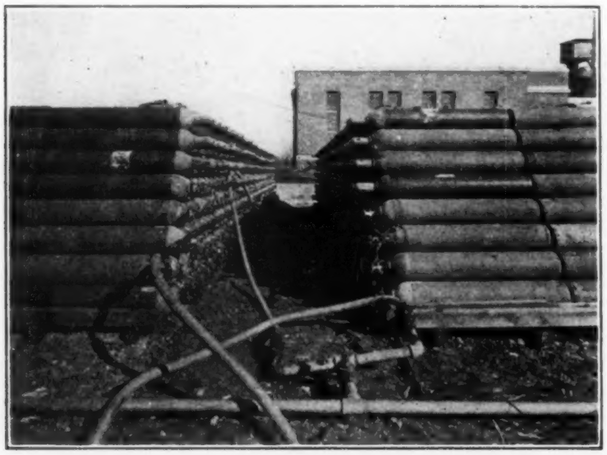


Fig. 7 Method of Discharging Helium From Small Cylinders at Lakehurst

cu. ft. The total lift or buoyant effect of the helium in these ships will be over 422,000 lb. The actual weight of the helium used will be 71,500 lb., or over 35 tons.

Outside of the aeronautical field there are few uses to which helium is now put. The largest use is perhaps for the inflation of toy balloons, and the next largest volume goes for research work. As this latter progresses it is quite certain that increasing uses will be found for the gas.

Use of Helium in Airships

The first serious suggestion to use helium for the inflation of airships was made in England in 1914. As soon as the United States entered the war the matter of using helium in airships was brought to the attention of the Army and Navy officials and immediately met with a very favorable reception. Funds were allotted, and three experimental plants were built immediately. The results of these experiments pointed to the fact that the production of helium was feasible and that helium could be made at a reasonable price. For that reason the Government built a large helium plant at Fort Worth, Tex., which was under the direction of the Naval Bureau of Steam Engineering, and which produced, during its life, about 50,000,000 cu. ft. of helium. This plant has now been abandoned. In its stead the Bureau of Mines has built a new plant of large capacity near Amarillo, Tex. The manufacture of helium on a large scale by the Government tends to make it difficult for private individuals to establish themselves in the business.

The use of helium in airships presents two or three special problems, chief of which is the saving of helium. It is necessary that airship fabrics be tight so as to avoid loss of helium, and that means be provided to prevent valving of the gas in maneuvering the ship. The first of these problems has been taken care of through the use of goldbeaters' skin as a lining for the gas cells, and the second through the use of condensers for recovering water from the exhaust of the engines.

Assuming a 6,500,000-cu. ft. ship, the total lift will be 422,000 lb. The lift of the same ship, using hydrogen, will be 455,000 lb., therefore the gain in lift by using hydrogen is 33,000 lb. Recent tests have shown that hydrogen can be used mixed with helium to the extent of 20 per cent by volume without danger of the mixture's being inflammable. Methods of purification have been devised for purifying this hydrogen-helium mixture without any danger of explosion. Therefore with an 80–20 mixture of helium and hydrogen the total lift of a 6,500,000-cu. ft. ship would be 429,000 lb., or a gain by using 20 per cent hydrogen of 6500 lb. or a little better than three tons.

The helium requirements for the operation of an airship of 6,500,000 cu. ft. capacity for the first year are about 13,000,000 cu. ft., of which 9,100,000 cu. ft. will remain at the end of the year.

In major airship operations a helium purification plant is necessary. A complete purification plant, including building, consisting of two units with all necessary piping and auxiliaries, will cost around $165,000. Experience indicates that the helium

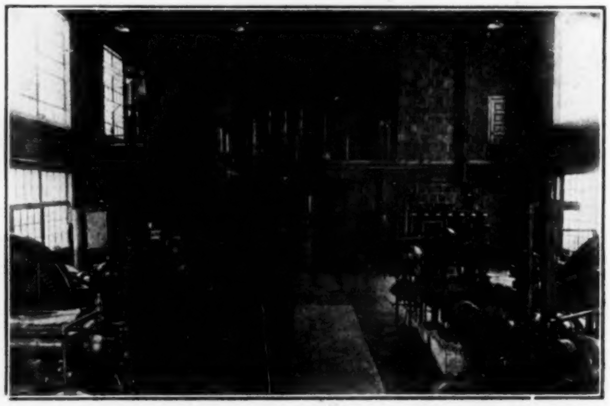


Fig. 8 Interior View of Helium Purification Plant at Lakehurst

in a ship under usual operating conditions should be purified about four times per year. The cost of purifying helium is approximately $1 per 1000 cu. ft.

It has been estimated that the investment in helium storage, tank cars for transportation, and purification facilities at an airship terminal, for four ships, would be about $1,095,000, and that the investment in helium (23,000,000 cu. ft. for four ships plus 3,500,000 cu. ft. reserve) will be $1,068,000, or a total of $2,163,000. The total annual cost of helium for four ships, including depreciation, insurance, maintenance and repair, loss of helium, labor, administrative overhead, purification, etc., is estimated at $1,105,000.

There will also be required perhaps 500,000 cu. ft. of helium storage in each foreign port, which will increase the investment in storage facilities by about $40,000 and the helium inventory by about $25,000.

By using 20 per cent of hydrogen in the helium, it would be possible to effect a saving of $116,000 per year for four ships.

If hydrogen were used alone, and estimating the cost at $2.50 per M cu. ft., the loss through valving to maintain purity, especially if that purity is maintained at a point to give any advantage over the use of helium, would amount to 500 per cent of the total volume per year. Therefore the annual cost of hydrogen would be $80,000 less per ship. However, the saving in insurance would be very much greater than this.

Surface Hardening of Steel by Nitrogen

A Discussion of the Position of Nitrided Steels as Engineering Materials, and the Practical Status of the Process

By H. W. McQuaid,[1] Detroit, Mich.

The constant demands of the designing engineer for better materials of all kinds to produce mechanisms to meet the ever-increasing demands for stronger, faster, lighter, and safer equipment have resulted in a great effort on the part of the metallurgist to meet the needs of the engineer. The fact is that the requirements of the engineer for materials, particularly metals, to withstand greater stresses at higher temperatures, and to resist abrasion at higher speeds and higher unit pressures have created great problems in the metallurgical world which are being concentrated upon with all the available skill and resources of the American metallurgist. This has resulted in increasing greatly the importance of the metallurgist in modern industrial life.

Contributions which the metallurgists have made to engineering in the past decade have been quite noteworthy, and it is safe to say that the next ten years will show much greater developments than have the past ten years. One of the most recent contributions has been the developments in the surface hardening of steel by the addition of nitrogen instead of carbon to the outer portion. About 1925 the engineering world received the announcement that Dr. Fry of the Krupp Works in Germany had developed a process called "nitriding," whereby special steels could be treated with ammonia and thereby given a surface which was harder than any testing instrument could check, which would resist corrosion, and which would retain its properties at an elevated temperature. As is usual with such publicity, an immediate and widespread adoption of this process was predicted, but as is also generally the case, the subject developed slowly, and it was found that the special steels were high in price, hard to get, that the process required a very long time, and the results were uncertain. The metallurgists in investigating it found that it was the adoption of a much older process to a special steel and that the important contribution of Dr. Fry was not so much the process but the addition of aluminum to a steel to give it the properties claimed for after nitrogen hardening.

The engineer is interested not so much in the metallurgical details of a given process or a given material as he is in the new properties which can be developed by the process in a material so that the latter becomes to him more useful or more economical than the materials he is using. Up to the present it has been customary for the engineer, where surface hardness is required, to specify that the piece be case-hardened, and if exact size is desired that the piece, in addition to being case-hardened, be finish-ground. For many purposes this has been a very desirable method, especially since the low-carbon, easily machinable steels can be made into parts which have a very high surface hardness, and which give very good results in such parts as gears, pins, bearings, etc. where a hard surface is advantageous. If special strength or special properties are desirable, the physical properties of the hardened surface can be improved by using special alloyed steels which are standard with the steel maker, and which are easily obtainable at a price which is strictly commercial. When high surface hardness is obtained with steels of high carbon content, such as tool steel, the depth of hardening is such that the piece becomes unsuitable for the purposes intended because of its tendency to be brittle, with consequent inability to withstand shock loading.

The case-hardening process, while it had the foregoing advantages, also had several disadvantages, some of the most important being the distortion encountered in the finished part, the tendency to soft spots, and the general lack of control due to the great variation which occurred with slight changes in the relatively high temperature employed. It is not unusual to have whole batches case-hardened too deep, to get a very high percentage of material which does not give the required hardness, or to have the warpage so great that the parts will not clean up in grinding. The disadvantages of case-hardening have not been so impressive to the engineer since they are difficulties for the metallurgist to handle, but nevertheless they add considerably to the cost of case-hardened parts.

In nitriding we are offered a material which can be given an extremely hard surface, which does not distort in the hardening process, and which is resistant to corrosion and to elevated temperatures. The object of this paper is to state as briefly as possible what the nitriding process is, what materials are required, what the disadvantages are, how it can be tested, and to what applications it is the most suitable. It is hoped that these will be presented so that they will satisfy the designing engineer's viewpoint.

Steels for Nitriding

In June, 1913, Adolph Machlet, of the American Gas Furnace Company, was granted a patent on a process for giving iron or steel a superficial hardness by heating it in an atmosphere of ammonia at a temperature above 900 deg. fahr. As described by him this process had only a limited application due to the fact that while with ordinary iron and steel an extremely hard, non-corrosive surface can be obtained, the hardened zone is so extremely thin that it does not offer much resistance to abrasion and is of little value even under relatively low unit pressures. Where the unit pressures are very light, and the resistance to corrosion is an advantage, the Machlet treatment can be used to good effect. In 1924 Adolph Fry, of the Krupp Company in Germany, discovered that the addition of aluminum, chromium, and several other metals to the steel to be hardened resulted in a great increase in the depth of hardness obtained. He recommended that the process of hardening these special steels by ammonia should not be done at a temperature higher than 1075 deg. fahr., and in fact insisted that above this temperature the results obtained would not be commercially satisfactory. As described by him, the process required many hours to produce a satisfactory case, usually about 90 hours at 950 deg. fahr. It was also found that even at the lower temperature, the case of the nitrogen-hardened pieces was extremely brittle. To this process of surface hardening by means of ammonia the name of "nitriding" was given, which indicates that the hardening is due to the formation of metallic nitrides of iron, aluminum, chromium, etc.

Using the chrome-aluminum steels, which were quite difficult to make and machine, many articles were hardened satisfactorily,

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Presented at a meeting of the Chicago Section of the A.S.M.E., Chicago, Ill., March 18, 1929.

and the results obtained were sufficient to give the nitriding art considerable publicity. It was found, however, that the addition of a small amount of molybdenum would materially reduce the notch brittleness of the nitrided piece, and at the present time practically all the nitriding steels contain molybdenum. Some of the special nitriding steels contain only molybdenum and aluminum as the characterizing elements. Others contain chromium and aluminum as these elements, with a small percentage of molybdenum added to increase the toughness.

The strength of the finished nitrided article is of course dependent upon two factors, namely, the strength and toughness of the hardened surface, and the strength and toughness of the core after the nitriding operation. If the hardened surface is extremely brittle, a load which results in fracture of the surface will be transferred to the core so quickly that fracture is immediately certain. It has been found with the nitrided material that, when the core has been properly treated and is large in proportion to the thickness of the nitrided case, the case will crack and the core will bend, a condition which is seldem found in the ordinary case-hardened piece. The core strength of the nitrided piece depends of course upon the alloy content and also upon the carbon content. Machining is affected very greatly by the carbon content, and hence for good machining it is desirable to have the carbon content low, but for high core strength and the best nitriding results it should be relatively high. For this reason nitriding steels vary in carbon content from approximately 0.30 to 0.50 per cent. Before nitriding, the special steels used will show when heat treated a yield point varying from 125,000 to 160,000 lb. per sq. in., depending upon the carbon content and the nitriding temperature. After the nitriding is done at 1200 deg. fahr. the core strength is of course reduced. Inasmuch as the strength of the case really controls the strength of the parts and failure of the case results in failure of the part, the core strength is not of much value to the engineer. It has been the author's experience that very few engineers in designing parts to be made from case-hardened steel pay any attention to the special physical characteristics involved in such material; and blissfully make calculations based upon the estimated core strength, and neglect entirely the fact that failure of the case is practically always the criterion in failures of such parts.

Owing to the relative newness of the nitriding art, particularly as appled to the analysis of the material needed, the exact status of the special steels required is somewhat uncertain. Much work has been and is being done to develop improved steels for nitriding, and no doubt many suitable ones will be developed in the next few years. It is characteristic, however, of all the steels developed to date that the important element is aluminum, and the hardness imparted by nitrogen to aluminum-bearing steels is probably due to the great stability and hardness of the aluminum nitride. As mentioned earlier, molybdenum is of advantage in the nitriding process since it tends to improve the toughness of the finished article. Such elements as chromium, manganese, titanium, tungsten, vanadium, etc., form nitrides which tend to increase the hardness, although hardness readings as high as 1250 Brinell have been obtained with molybdenum-aluminum steels when the process has been altered to suit this particular type of steel. Apparently those elements which form carbides in the steel also form nitrides, with a resultant increase in hardness.

The cost of the steels employed in the nitriding process is higher than that of the steels used for case-hardening. This, to the engineer, is of greatest importance since it affects adversely the cost of the nitriding process in its competition with the case-hardening operation. At the present time one of the best-known and well-advertised nitriding steels is quoted at approximately 12 cents a pound for ordinary consumption, and as low as 7 cents for requirements of 1000 tons per annum—this as compared with approximately 2 cents a pound for low-carbon case-hardening steels and approximately 4 cents for the better-grade alloy case-hardening steel.

To overcome this handicap of initial high cost it is necessary that the results obtained in the finished article shall be ultimately economical as compared with the case-hardened steel part. There are many instances where the losses which are met with in case-hardening products due to soft spots, warpage, etc., are sufficient to make it well worth while to pay the higher cost of the nitriding steel with its lower losses in the finished article. In other cases the nitriding steels have to compete with the higher-priced stainless steels, and here the results are greatly in favor of the nitriding steels for such parts as pump shafts, valve seats, etc. There is no doubt but what the engineer will be specifying nitriding parts to replace stainless steel, monel metal, etc., in large quantities in the very near future. This is particularly true where not only is corrosion an important factor but hardness at elevated temperatures.

The nitriding process as now carried on consists in subjecting the parts to be nitrided to an atmosphere of ammonia at a temperature somewhere between 900 and 1200 deg. fahr. The time required depends upon the method and materials used, and varies greatly. It also depends to a great extent upon the use to which the nitrided article is to be put, varying from as little as one hour to as much as 100 hours.

It has been found that the best results are obtained when the nitriding steel is in what is known to the metallurgist as a sorbitic condition. This condition is obtained by quenching from above the critical range and then reheating and cooling slowly from a temperature below that range, generally in the neighborhood of 1100 deg. fahr. When the nitrided piece has been so treated the ductility of the finished article is greater and the tendency of the case to spall is greatly reduced. It is also important that the surface of the piece to be nitrided be clean, as some varieties of dirt and foreign matter exert a great influence upon the results obtained; and since it is not known exactly just what is harmful, it is best to prescribe a thorough cleaning either in a boiling caustic solution or gasoline. No surface on which satisfactory nitriding is to be obtained should be decarburized; i.e., sufficient material should be machined off to get below any decarburization resulting from the oxidization met with in rolling or forging.

The Commercial Process of Nitriding

The nitriding furnace may be of any design suitable to heat the retort employed to handle the work in process. However, the low temperatures lend themselves to electrically heated furnaces, and such furnaces have been found to be very desirable, especially when equipped with automatic temperature control. Gas-fired furnaces can be used just as well, and with equally good results, and the cheapness of such equipment might be a factor in deciding on which to build. The retorts in which the work is to be treated with ammonia should be made from a material which does not nitride easily, and it is therefore usual to construct them from an alloy high in nickel, of which latter there are many on the market such as nichrome, etc. Inasmuch as ammonia is expensive and its fumes are irritating, it is very desirable to seal the retort as tightly as possible and hence special covers are designed in which the seal is obtained by using various clamps, etc., in combination with gaskets of asbestos, nickel, and other materials. At the Timken-Detroit Axle Company satisfactory results are obtained by using a heavy nickel sheet for a cover and clamping this to the machined surface of the retort with a small amount of sodium silicate as a seal. In some furnaces the cover or door is sealed with an oil or similar

seal, and the work placed in baskets instead of retorts. This facilitates greatly the loading and unloading of the furnace.

In designing the nitriding furnace and laying out the nitriding department, one of the most important considerations is that of providing facilities for eliminating the ammonia fumes. Since these fumes are very irritating it is difficult to keep men working where they are pronounced. If the retort type of equipment is used, care must be taken to insure tight connections from the ammonia tank through to the water seal, and the escaping ammonia from the outlet pipe should be discharged in a small stream of running water. Special care should be given to handling the retort in and out of the furnace, and to closing up the latter when the retort is in place. At the Timken-Detroit Axle Company the retort is provided with tracks on the bottom which run on nickel-chrome rollers. The retort is handled in the loading position in front of the furnace as shown in Fig. 1, by means of these rollers. The inlet and outlet pipes for the ammonia are brought down close to the front of the furnace, and an asbestos mat provides the tight seal under the furnace door.

If the open type of furnace is used with a sealed cover, it is well to remember that the resistors operate at a much higher temperature than the furnace, and tend to increase the dissociation of the ammonia.

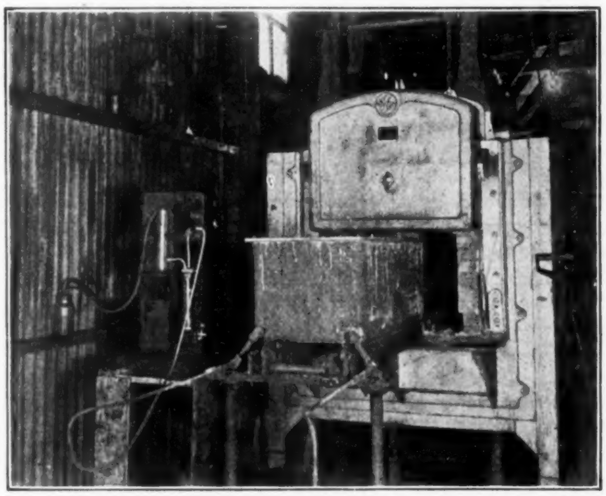

FIG. 1 SHOWING RETORT AT ENTRANCE TO NITRIDING FURNACE

It should be borne in mind in designing a nitriding furnace that considerable time is lost if it is necessary to cool the work in the furnace; this is quite necessary in the basket type of furnace, but not in the retort type unless the high- and low-temperature method is employed in the nitriding operation. In this case much time will be lost in cooling the work so that it can be exposed to the air or so that the change from the high to the low temperature can be made, and it is well to provide a cooling system which will reduce the furnace temperature as rapidly as possible. In the ordinary nitriding operation a good cooling system will save from two to four hours per run, which is a very important consideration.

The standard commercial ammonia which can be obtained in most cities in 100-lb. tanks has been found to be very satisfactory for the nitriding process, and the usual method is to pipe the ammonia from the ammonia tank through a reducing valve to the retort and from the retort to a water seal which indicates the pressure maintained in the retort. This pressure is ordinarily approximately an inch of water, so that rubber hose can be used conveniently to permit of movement of the retort without breaking the connections. It is well to equip the ammonia tank with a pressure-indicating gage at the reducing valve, and to place the tank so that liquid ammonia will not enter the system.

It has been found that the nitriding process can be speeded up very greatly by increasing the circulation of the ammonia through the work. Apparently there is a tendency for the surface of the work to become passive, and for the nitriding action to proceed slowly unless fresh ammonia is continually brought into contact with the work. For this reason it is very desirable to circulate the ammonia as rapidly through the retort as possible, or to provide a circulating system in connection with the retort itself. This has been done by the Leeds & Northrup Company by adopting the Homo furnace for nitriding. This furnace contains a circulating fan which reverses its direction at regular intervals, and hence keeps a rapid flow and continuous agitation of the ammonia through the work.

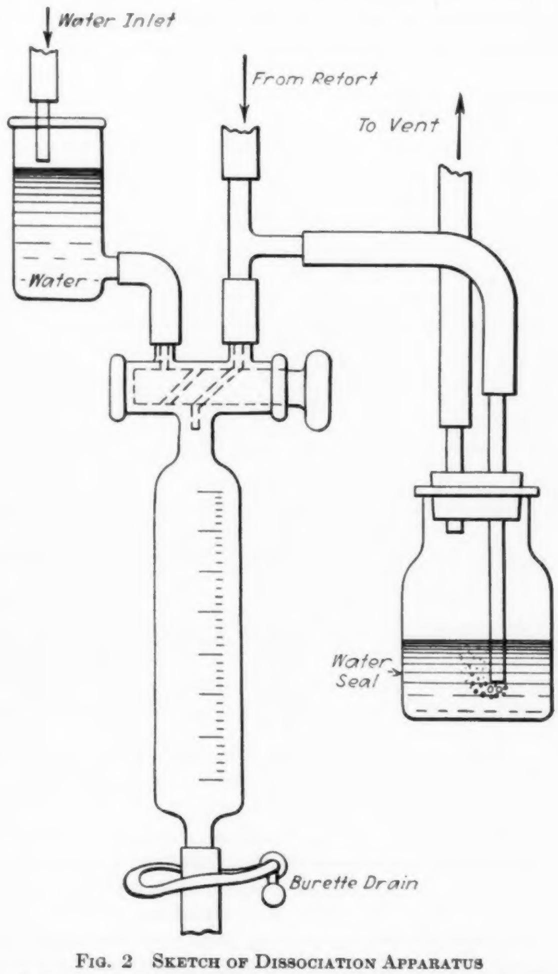

FIG. 2 SKETCH OF DISSOCIATION APPARATUS
(Gas from retort is mixed with water in closed burette, and percentage of undissociated ammonia determined by level to which water rises in burette.)

When ammonia is heated, especially in contact with iron, it dissociates into hydrogen and nitrogen to an extent depending upon the temperature. It has been found desirable that this dissociation which takes place in the nitriding retort be kept to a certain minimum. Whether the important factor is the dissociation of the ammonia or the flow of the ammonia is not certain. It is the author's experience that the dissociation in itself can be disregarded and that the contact of the surface of the work with the ammonia, and therefore the percentage of undissociated ammonia in the retort and the circulation,

is the important factor; i.e., with a high degree of circulation the dissociation can be relatively great without any adverse affect on the work itself. Thus we have found in nitriding at 1200 deg. fahr., where the dissociation is hard to keep below 50 per cent, that very satisfactory results are obtained provided the flow of ammonia is sufficiently rapid through the work.

It is well to have a simple dissociation check apparatus set up to determine the percentage of undissociated ammonia coming from the retort. This can be done using a set-up such as that shown in Fig. 2.

After the type of furnace and the department layout are decided upon, the next important step is to determine at what temperature and on what cycles the nitriding is to be operated. According to Fry, no nitriding should be done at a temperature above 1075 deg. fahr. If this is done, according to the same authority the marginal layers will be brittle, tend to peel off, and give no surfaces suitable for parts which are subjected to severe strains. For this reason most of the nitriding which is being done is being kept below 1000 deg. fahr. with the result that the time required is often as much as 100 hours and the nitrided zones are relatively thin. They are, however, extremely hard.

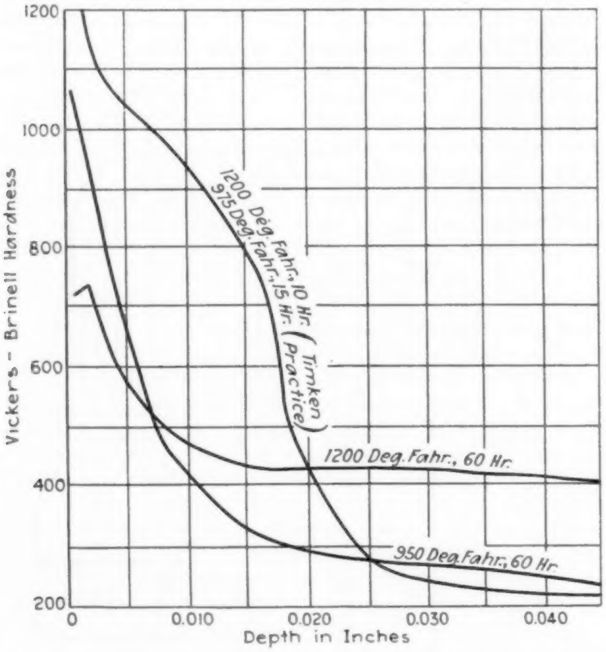

Fig. 3 Effect of Temperature on Depth-Hardness Curve for Molybdenum-Aluminum Nitriding Steel Nitrided as Shown

This is not necessary, however, since it is possible to obtain a very hard, adherent case at temperatures as high as 1200 deg. fahr. which compares very favorably with those obtained at the lower temperature. In fact, some of the toughest and most satisfactory nitrided cases have been obtained by nitriding at a temperature of 1200 deg. It has been the author's experience that as the temperature increases from 900 to 1250 deg. the surface hardness decreases, but the depth of the nitriding effect is greatly increased for a given time. Therefore, for many purposes a run of 20 hours at 1200 deg., while it does not give a case which is as hard as would be obtained at the lower temperature, will give one which is very much deeper than would be had from a run, say, of 90 hours at 950 deg. Fig. 3 shows the depth-hardness curves obtained at different temperatures and Fig. 4 the results obtained at the low temperatures for different periods of time. At the Timken-Detroit Axle Company the knowledge obtained from the depth-hardness checks has led to a cycle which has been found to be very satisfactory. This consists of a 10-hour period at 1200 deg. fahr., followed by a 15-hour period at 975 deg. Using this method, Brinell hardnesses as high as 1200 have been obtained with a depth as shown in Fig. 4.

If the ammonia is mechanically circulated during the operation, the time cycle can be still further reduced, and very satisfactory results have been obtained using a 6-hour period at 1200 deg. fahr., followed by a 10-hour period at 975 deg. with a total cycle of approximately 18 hours.

If the main object of the nitriding is to insure a non-corrosive surface, such as on pump shafts and similar applications, the nitriding cycle can be reduced to a few hours; while if the maximum case is required it is believed that by using a cycle similar to the foregoing it is not necessary to nitride on a cycle totaling more than 30 hours. Since the proper nitriding temperature varies somewhat with the steels used, it is well to experiment in order to arrive at the most satisfactory one. The molybdenum-aluminum steels seem to require a higher temperature than the chromium-aluminum, and considerable experimenting with the various steels, cycles, etc., is advisable before setting the practice to any given cycle or steel.

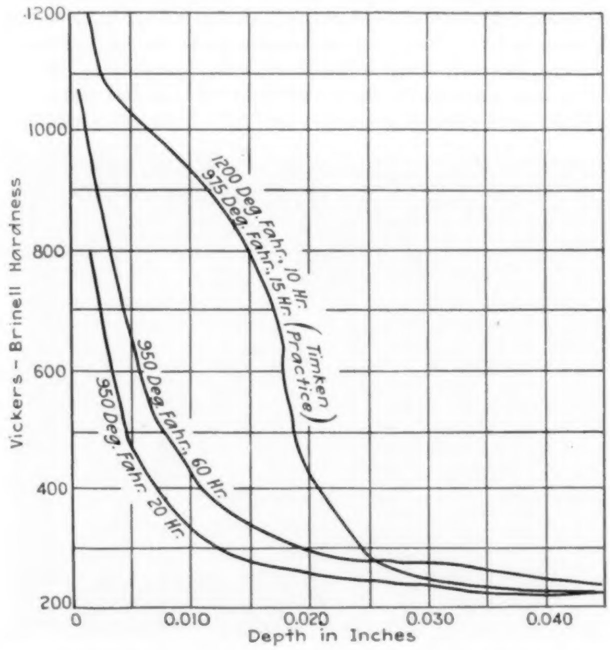

Fig. 4 Effect of Time on Depth-Hardness Curve for Molybdenum-Aluminum Nitriding Steel Nitrided in Ammonia as Shown

If it is desirable to finish up with a surface which is as free as possible from discoloration, it will be necessary to permit the work to cool down in the atmosphere of ammonia to a temperature of not more than 350 deg. fahr. If the treated parts are exposed to the air at a temperature above this, they will have a blue oxide finish which is in itself softer than the nitrided case beneath. For this reason, where the sealed furnace is used for nitriding, cooling means should be applied to the furnace to reduce the time required to cool to 350 deg. to a minimum.

Results Obtained With Nitriding Process—Applications

If everything has gone well with the nitriding process and the

above-mentioned precautions have been taken, the work when removed from the furnace or retort should possess a light silvery gray finish which is very smooth and absolutely file-hard. A dusty or powdery finish indicates that some detail has not been carefully attended to, either in the cleaning of the surface or the circulation of the ammonia. If the surface is very satisfactory but very thin and underlaid with a very soft zone, it is evident that the hydrogen has been more active than the nitrogen and that there has not been enough circulation of the ammonia over the surface to be nitrided.

The surface should not only be hard but it should be able to withstand heavy blows and considerable pounding without movement. The edges, if they possess even a very slight radius, should not flake when pounded with the hammer, and flat surfaces should withstand pounding with the peen end of a hammer without cracking. One of the best indications of good results in nitriding is a very smooth finish combined with an absolutely file-hard surface. If a section is ground and etched with a nitric acid solution, the nitrided case will be developed and its total depth can be ascertained easily. The depth indicated by the etch, however, is not indicative of the actual depth of file-hard material, as this is seldom more than 0.010 in.

If the work has been carefully measured before nitriding, a recheck will show that warpage is commercially negligible although the nitriding process has been accompanied by a change in size. This increase in size will approximate 0.001 in. per inch of diameter, and has been found to be quite uniform, so that it can be allowed for in designing parts made from the nitriding steels. Very intricate parts have been made and nitrided because of the very desirable lack of change of shape exhibited by the finished material. Because of the high price of the nitriding steels and the newness of the art, the field of its application has as yet practically been undeveloped. It can be applied to any part which is to be subjected to heavy abrasive loads, and in fact wherever case-hardening is now used, with the possible exception of extremely heavily loaded carburized parts for which such steels as the 5 per cent nickels, nickel-molybdenum, etc., are now required. The nitriding steels are less resistant to high concentrated shock loads than are the high-alloy case-hardening steels, but in such parts as wristpins, timing gears, worms, journals, etc., the nitriding product is very superior to the case-hardened one. Most of the work done to date has been of an experimental nature, and thousands of tests are being made on all classes of work using nitrided parts. It is in everyday commercial production on parts such as pump shafts, vacuum-cleaner beater bars, valve seats to withstand high temperature and pressures, airplane-engine timing gears, and hundreds of parts requiring the highest degree of hardness with the least distortion. One consumer alone has need of approximately six tons of nitriding steel per week to satisfy his requirements.

Due to the price of the nitriding steels, many parts are excluded from nitriding because of the extra cost involved. Thus in the cheaper applications of the case-hardening process where plain carbon steels are used, the nitriding process cannot compete because of the initially higher cost of the material. For such parts as pump shafts and those where corrosion is an important factor as well as hardness, the nitrided part can be very economically employed since in this case it has only to compete with stainless steels which sell for a much higher price.

For such parts as bearings, gears, etc., whose manufacturers are at the present time probably the greatest users of case-hardened high-grade alloy steels, nitriding has still to be successfully demonstrated. There is no doubt, however, but what the lack of distortion and the superior hardness of nitrided parts will for these purposes some day be combined with toughness and machining factors which will make nitriding a standard method for treating such parts. Nitriding steels, due to their high alloy and carbon content, are much more difficult to machine than the low-carbon case-hardening steels. According to information which the author has, several very prominent European automobiles have used ring gears and pinions of nitrided chrome-aluminum steel, with extremely satisfactory results. In fact, if reports be true, one of the most expensive European models has practically eliminated case-hardening and replaced all parts formerly so treated with nitriding steels. Attempts so far to duplicate the European results in American gear applications have not been successful, although the author is convinced that this field will soon be open to nitriding steels.

From an engineering standpoint, serious consideration should be given to the use of nitriding steels as a means of combating corrosion and eliminating wear and distortion. The engineer should weigh carefully the advantages of the nitrided part as compared with the case-hardened part or the stainless-steel part.

As a word of caution, it must be admitted that some very poor results have been obtained with nitriding, but this has been because some simple factor in the process has been neglected. It is also well to remember that the nitriding art is in its infancy, and also that much effort and money are being expended at the present time to improve the process and develop cheaper and more satisfactory steels, and it is safe to say that the next few years will without doubt see the elimination of most of the objectionable factors at present entering into nitriding. All that is necessary is an insistent demand from the engineering profession that the metallurgist produce, and the results will follow to a degree depending upon the pressure applied.

Nitrogen Hardening

FOR crankshafts a moderately hard grade of Nitralloy steel is recommended, and they may be rough machined sufficiently closely to the finished sizes to permit of rectification of any distortion set up by oil hardening. When hardening at 850 to 875 and tempering at 650 to 700 deg. cent., a tensile strength of 54 to 57 tons per square inch is obtained. Simple crankshafts can then be machined to the finished sizes and nitrated. Larger shafts, the production of which involves widely varying forging stresses, should, however, be annealed for a few hours at 500 to 550 deg. cent. prior to finish machining. In this case the bulk of the stock would be removed before annealing, leaving an amount sufficient to allow for the correction of released stresses. The shaft would then be finally finished to size prior to nitration.

The swelling due to the final hardening consists in part of a slight film of oxide, and at least half of the increase in diameter on the bearings can be removed to advantage, since the maximum hardness is below the surface of this film. Emery paper may be used, or for high-grade work a further rectifying operation, such as lapping or honing. In any event the amount actually removed should not exceed 0.004 on the diameter of the bearings.

An interesting possibility in connection with nitrated crankshafts is the elimination of anti-friction liners, excellent results being obtainable with duralumin connecting rods running direct on the pins. This also enables the width of the connecting-rod bearings to be reduced, with a corresponding reduction in the overall length of the shaft and engine.

For gears the procedure follows a similar sequence of rough machining, oil hardening and refining, a first finishing operation, annealing, final finishing, and nitration. This, however, is an ideal sequence which may not be absolutely necessary in every case. *The Automobile Engineer*, March, 1929, page 93.

Modern Practice in the Installation and Starting of Hydroelectric Units

By CHARLES V. FOULDS,[1] SAN FRANCISCO, CALIF.

The development of the huge modern generating unit has in general made it impossible to assemble in the manufacturer's works more than certain aggregations of parts of a single unit and to depend, as formerly, on the accuracy of machined fits. The author outlines various measures which will facilitate the accurate erection of large-size units, following which he discusses the support of heavy parts during setting operations; bearing problems; and preliminary operation at reduced speed. He concludes that no amount of engineering supervision or careful layout of tools and methods of assembly can possibly be a substitute for a man of the broadest experience to intimately and personally direct all of the assembly work down to the smallest details.

PROGRESS in the design and construction of hydroelectric generating units during recent years has been largely in the direction of increased size and capacity, with refinement in operating characteristics and controls, and with this progress there has come a corresponding development in the practices followed in the installation and starting of the increasingly complex mechanism.

The earlier machines were, as a rule, small in size and more or less self-contained, and in consequence formed fairly rigid structures. Such machines were usually nearly if not completely assembled, and correlated parts doweled in their correct positions, in the manufacturer's works prior to shipment, frequently on one-piece baseplates, so that final installation involved little more than reassembling them on foundations with the proper connections to penstocks and other related parts.

The development of the modern generating unit has been distinctly away from these factors that contributed to the ease of correct assembly of the older ones, and in consequence the entire technique of assembly has been changed. It is no longer possible, in many cases, to assemble in the manufacturer's works more than certain aggregations of parts of a single unit, and these groups of parts are not combined into the complete hydroelectric unit until the final assembly at the time of installation. This condition applies both to the hydraulic and electrical equipment forming a hydroelectric generating unit, and requires as a rule that much of the work done in the field shall be of a nature that would in former times have been considered shopwork.

Large generators are shipped with the frames, laminations, coils, poles, and rotor segments in separate packages, which parts have at no time been assembled together in their entirety, but have been simply compared each one with its matching part and with possibly minor partial assemblies to make certain of the proper dimensions and fits of other related parts. In the case of the water wheel or turbine, the principal parts are practically all packed separately for final assembly in the field. In the case of turbines, particularly those with plate-steel casings, the plates are shop-fitted in so far as it is possible and matched with one another, and then knocked down for separate shipment. Final assembly, including the riveting and calking of the joints, testing, etc., is only done after erection in place. In the case of water wheels, the buckets may be shipped separately from the wheels or disks, and the nozzles, valves, and other parts sectionalized to the greatest possible extent. Water wheels being usually for higher-head applications, the individual parts and part assemblies can more often be completed at the manufacturer's works and the problems of distortion and final assembly do not enter to the same extent as with reaction turbines; but in most cases, and varying in degree only, there is necessity for performing in the field operations usually associated with manufacture, and which require special field tools and equipment as well as workmen who are specialists in their particular lines.

Dependence Formerly Placed on the Accuracy of Machined Fits

With the older units, the greatest dependence was placed on the accuracy of machined fits, particularly for the centering or otherwise correlating of various parts required to work in combination. When individual parts consisted of single, comparatively small and rigid structures this practice was possible, but with the modern increase of size and resultant flexibility of individual parts, together with the difficulty of machining them with the absolute accuracy of smaller ones, there has come the necessity for developing design features that will to the greatest possible extent eliminate the dependence upon the accuracy of individual machining operations, and provide means for the convenient neutralization of any such minor errors as may remain in completed parts. Aside from the physical handicaps of following the older system, this is made desirable by the difficulty of the manufacturer's discovering the minor errors that would normally be brought out by shop assembly and which, if discovered at the time of manufacture, could be easily corrected by the tools used in the original fabrication of the parts. Where major parts are for the first time correlated with their matching parts in the field, any errors, even if slight, may be extremely difficult to correct owing to the absence of tool equipment, and means for eliminating the effects of any such errors become essential parts of the machine design.

In addition to those irregularities that may occur through errors or distortion of the parts during manufacture, the large sizes of such parts render them liable to distortion during shipment or assembly on their foundations, or due to aging of the castings and to distortions that may occur subsequent to the grouting operations owing to settlement or shrinkage of foundation structures or of large masses of grout. In fact, there are certain portions of units that are advantageously made to provide for the correction of misplacements that may result from settlement or shrinkage during the operating life of the machine and after the erection period is entirely past. Obviously the means required to provide the necessary flexibility and adjustment are many and varied, and depend on the individual design of the machine and the particular conditions surrounding its installation.

Measures Which Will Facilitate the Accurate Erection of Large-Size Units

To facilitate the accurate erection of large-size units it will

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be found advantageous to give consideration in the design to the following principal points:

a Provision should be made for adjustment at the inlet pipe connections to the turbine casing or nozzle body to permit the casing or nozzle to be set exactly in its proper position, and level, without regard to the exact position of the penstock terminal flange; assuming that the penstock is in place prior to the mounting of the machine. This element of flexibility may be obtained by means no more complicated than the leaving loose of a companion flange or other riveted joint, so that after erection of the casing and penstock is completed the rivet holes may be finally drilled to match and the rivets driven with the parts in their ultimate location.

b Grouting clearances should be provided for draft tubes, wheel-pit frames, and similar parts, so that there may be a slight latitude to make up for irregularities of the parts in question or in the foundation.

c Foundation bolts should be arranged either with grouting tubes of ample diameter to permit considerable lateral adjustment, or much better still, when conditions are favorable, cored pockets should be provided in the foundation to receive the bolts, and the bolts themselves should then be hung loosely in these pockets from the parts to which they attach, the pockets being filled with grout at the time the remainder of the equipment is secured to the foundations. Foundation bolts are a particular source of annoyance, expense, and delay if not handled along the lines suggested, for the reasons that there may be errors in the location of the holes into which the bolts are to fit, errors in the locating of the bolts during the process of pouring the foundation when reference lines are difficult to maintain, or circumstances may make it desirable to shift the position of the entire unit by a small amount.

d Governor connections, both mechanical and oil-piping, should be made as flexible as possible, in order that there may be no difficulty in locating the governor in its proper relation to the machine. Frequently the one most important connection may be made rigid. The governor position will then be determined by this one connection, and all other connections should be made sufficiently flexible to accommodate that particular position.

e Auxiliary piping for water or oil should be either laid out so as to provide natural flexibility through the swiveling of flanges or screwed joints, or else flanges at strategic points should be left loose for welding in place to the pipe after all of the various items of equipment are fixed.

f The head covers of turbines and the like, where the greatest accuracy of relative location is required, should not be provided with centering fits or other restrictions to slight movements within the normal clearances of bolt holes. In cases where the greatest precision is required, portable machines may be constructed for machining in place certain of the matching surfaces vital to the absolute alignment of the important machine parts. Even where this practice is followed, some measure of adjustability is still desirable in order to compensate for changes that may result from aging of the parts or settlement and shrinkage of foundations.

Support of Heavy Parts During Setting Operations

The large size, great weight, and consequent tendency to distortion of the larger machine parts in the modern hydraulic unit present considerable problems in the support of such parts during the setting and grouting operations. It has become general practice to provide, for the support of such parts, screw jacks bearing on appropriate pads at selected points of the structure, which jacks are used for the leveling of the part and are then left in place and grouted in as parts of the foundation. The location of such jacks is worked out as a part of the design with a view to correct support of the member in question, and piers for their support are provided for in the design of the foundation, so that when such a large part is assembled it is not necessary for the erector to make up supports of such materials as he may find at hand. Various tension bars, struts, and rings are also provided on occasion to keep the large parts in shape during the erection operations.

Bearing Problems

Steady bearings for vertical units are made with just sufficient clearance to slip over the shaft, with the expectation that the proper running clearance will be produced by scraping after erection is completed and when the true ultimate relative positions of the shaft and bearing become known for the first time, thus permitting the clearances to be uniform and securing the fullest possible bearing. The bearings of large horizontal units are fitted in the same way and with even greater reason, for they are subject, in addition to the uncertainties of absolute shaft location, to the distortions and deflections of the shaft and bearing parts that occur under load. Where such procedures have been followed by competent men, it has become the rule rather than the exception to find it possible to so correctly fit bearings at the time of assembly that no refitting or even dismantling for inspection is required during the period of placing the machine in regular commercial service. Very considerable savings in time and costs are made where this result is secured, especially when it is important to have the unit in service at the earliest possible moment.

Where large pressure parts, such as turbine casings, are completely assembled for the first time in the field, it becomes necessary to provide special means and equipment for the pressure testing of such parts, involving diaphragms or heads to be used at the inlets, and dummy rings or other parts to seal off the various water passages.

Preliminary Operations at Reduced Speed

It is common practice to operate a newly erected unit for a period of several days at greatly reduced speed, in order to work in the bearings and get all of the various auxiliaries in proper working order before an attempt is made to run under load. In the majority of cases, this period of reduced-speed operation works in very well with the necessary period for the drying of the generator at reduced speed on short-circuit. On the other hand, where the delivery of water to a unit may be delayed much beyond the completion of the unit itself, and where the necessity exists to place the unit in service as quickly as possible after water becomes available, it is customary to dry out the generators by means of hot-air blowers, and to operate the machine for the necessary running in at reduced speed by motoring it from some near-by unit. The care exercised during the running-in period has a very great effect on the ultimate service that the machine will deliver, and if proper attention is paid to correction of minor difficulties during this period it is usually possible to have the machine in regular service, under load, within a very few hours after water becomes available or full speed is reached for the first time.

From the foregoing it will readily be apparent that the care exercised during the installation and starting periods will have a very profound effect upon the service that the machine will render. In fact, from the broad viewpoint the installation and starting represent the culmination of all of the manifold efforts that enter into a completed project, including the original conception, financing, general design, and machine design, and too much care cannot be given to assure the work's being done in the very best possible fashion. With the older machines of

smaller size and simpler construction it was frequently possible for the purchaser's engineers to supervise the work, but with modern equipment it has, through necessity, become the almost universal practice to depend upon the manufacturer's field engineers for the detailed supervision of the work, and in many cases, particularly with electrical equipment, it is necessary also to make use of skilled specialists from the manufacturer's works who are required to do in the field those operations which would usually be considered as part of the manufacturing processes. Through the greater experience that such specialists bring to the work by their intimate knowledge of manufacturing processes and the resulting higher quality of the work done, the use of factory engineers in most cases leaves the purchaser better pleased with the installation than if performed by his own men.

Installation and Starting Work Not Readily Susceptible to Engineering Supervision

Installation and starting work is of a nature that does not lend itself readily to general engineering supervision, for the reason that it is usually not possible to alter parts that are incorrectly assembled or set, they frequently being buried in concrete, nor is it possible in many cases to undo the results of a single false move during the starting period. This has led to the very definite conviction on the part of most large users and manufacturers that no amount of engineering supervision, or careful layout of tools and methods of assembly to be used, important as they are, can possibly be a substitute for a man of the very highest type and broadest experience to intimately and personally direct all of the assembly work down to the smallest details. In most cases such a field engineer, in addition to the actual services performed for the purchaser, forms the connecting link between the purchaser and manufacturer, bringing directly to the purchaser the engineering and manufacturing talent of the manufacturer's organization.

The ultimate satisfaction that a purchaser may feel with a given installation depends to a large extent on the way the installation and starting work has been carried out, and may depend on the personality as much as on the ability of the manufacturer's field representative. A competent representative will fit in smoothly with the purchaser's organization, conform to all of the rules and prejudices that exist in an organization of long standing, and will go out of his way to arrange his work to fit in best with that of contractors or groups whose work must contribute to or be correlated with his own. A manufacturer therefore does well to exercise the greatest care in the selection and training of men of the highest caliber for such work, since the purchaser's opinion of the apparatus supplied, and consequently the manufacturer's reputation, are largely in their hands.

Bromine From the Sea

BROMINE was found necessary for the manufacture of a chemical corrective for "knocking" in automobile engines. This chemical is ethyl fluid, made by blending bromine compounds with tetraethyl lead. It is added to gasoline to form ethyl gasoline, now sold at many filling stations. It was felt that the new demand might exhaust eventually the sources of supply previously in use. Could an inexhaustible source be found? Could bromine be gotten from it at reasonable cost?

There is only six thousandths of one per cent of bromine in sea water, a very minute quantity, about sixty-six pounds in a million. Yet the aggregate is huge. A plant producing 100,000 pounds of bromine each month would be supplied for 392 years by one cubic mile of sea. Geographers estimate that the oceans contain 418,000,000 cubic miles. Such examinations as have been made in various parts of the ocean indicate that bromine is uniformly disdistributed. Hence, for practical considerations, the claim that the sea is an inexhaustible source of bromine, is no exaggeration. However, along shore the sea water is at many places polluted, or contains silt or other matter in suspension, or is diluted by river water. Therefore, as in other industrial operations, the factory site must be chosen with knowledge.

First, the theoretical chemistry of the problem was studied. Early in 1924, the laboratory of the Ethyl Gasoline Corporation in cooperation with General Motors Research Laboratory, devised a method for getting bromine from sea water. The process was operated successfully in the laboratory and appeared to have possibilities for large-scale operation. E. I. du Pont de Nemours & Company and the Ethyl Gasoline Corporation undertook development. At Ocean City, Maryland, a semi-works scale experimental equipment was set up, comprising tanks, pipes, pumps, chlorinators, mixers, and filters.

To separate the bromine a chemical reaction was required. For this reaction, dilute sulphuric acid, chlorine gas, and aniline were found necessary. They must be introduced in the order named and very rapidly and thoroughly mixed with the water. Indeed, the aniline must be dispersed through the acidulated water almost instantly.

Ocean City experiments proved that bromine could be obtained in quantity from sea water. Success was shown to depend upon accurate control of the chemicals employed and their very rapid and complete mixing throughout the water as it passed through the apparatus. Serious difficulties arose from operating on water containing an appreciable quantity of suspended matter. The corrosive natures of the chemicals demanded that the equipment be of suitably resistant materials or absolutely protected.

Large-scale development next was undertaken. It was desirable to avoid the difficulties peculiar to shore water and to try clean sea water from a number of places. How could these ends be better attained than by installing the larger plant on a ship? A lake-type cargo steel steamship, 253 feet long, 43 feet beam, of 4200 tons dead weight, was bought. Within ten weeks she was overhauled, converted into a floating chemical plant, loaded with supplies, and sailed away on the first and only ocean voyage for the recovery of bromine.

From Wilmington the *S.S. Ethyl* steamed down the Delaware, out into deep water, and then southwestward to latitude 34, off the North Carolina coast, returning after a few weeks to Wilmington.

The quickly designed chemical apparatus, handling 7000 gallons of sea water per minute, worked satisfactorily from the first. A few minor difficulties were encountered and some trouble from corrosion. The experimenters believed that these difficulties could be surmounted and that their sea-going plant would operate satisfactorily in practically any weather up to half a gale. The intricate chemical problems had been successfully solved in an amazingly short period, and the chemical engineering was equally admirable. Bromine was produced in satisfactory quantity and at a cost, even with the temporary and uneconomical plant, which showed that if the market demand should justify the effort, bromine could be produced from sea water at a cost which would not necessitate an exorbitant increase in price. Although present demand does not justify immediate utilization of the knowledge gained, the industries of the nation have in reserve one more important resource. From "Research Naratives," July 15, 1929, published by Engineering Foundation.

The Present and Future State of Our Natural Energetic Resources

By F. M. Jaeger,[1] Groningen, Holland

It is a well-known fact that, both for the biological processes in plants and animals as well as for the maintenance of human civilization, a continuous import of energy from outer space to our planet is necessary. The only source of energy that practically needs to be taken into account in this respect, and which daily furnishes enormous quantities of energy, is our sun. In whatever form we meet with energy on the earth, whether it be stored in coal or oil, or be immediately available to us, as in the flowing or falling water or in the winds, it can in all cases easily be understood that this energy has always its real origin in that of the radiation which the sun continuously emits in all directions into space. If this radiation is absorbed, it will for the greater part be transformed into heat, which causes the water on the earth to evaporate, and thus gives rise to the mighty formation of clouds. Inversely, the condensation of this water vapor is the cause of rain and snow fall, which in their turn feed the rivers, seas, and waterfalls. The differences in temperature and pressure in the earth's atmosphere that are brought about under the influence of the solar radiation are the cause of air currents which give rise to the energy of the wind. The radiant energy of the sun given out several hundreds of millions of years ago is now stored up in the form of chemical energy in coal, after having been transformed and accumulated in the living vegetable cells of those far-off eras. Through the process of combustion this stored-up chemical energy is used by us in our steam engines and gas motors of today. This stock of coal, and also of mineral oil, nowadays represents the principal source of energy that man utilizes for the production of mechanical power. There is no other source of energy on the earth the output of which can even distantly be compared with that derived from the two sources just mentioned. We can safely say that practically our whole need of energy is supplied by that fossil stock of solar energy which is at present stored in our deposits of coal and oil. The necessary consequence of this is that we draw upon our energy capital to so great an extent that it must finally become exhausted, unless some way be found to replenish it by again accumulating this mighty solar radiation against the day when our stores of coal and oil will have been exhausted. The total quantity of coal on the earth seems not to exceed about 2000 billion tons, of which at the present time about 1.5 billion tons are used annually. This yearly consumption, however, is increasing so rapidly that our coal deposits will hardly be sufficient for another thousand years, a period that is very short in comparison with the length of the future existence of mankind on the earth. But the exploitation of the coal deposits that still remain will become impossible long before that time, both for technical and for economic reasons. Within a period much shorter than these thousand years the ominous consequences of the present reckless exhaustion of our coal fields will make themselves seriously felt, for the simple reason that the coal must be extracted from ever deeper and deeper levels, with consequent rapid increase in the cost of mining.

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Possible Sources of Energy Other Than Coal

The question as to whether it will then be possible to obtain the indispensable energy from other sources on earth must, so far as can now be judged, be answered in the negative. At the instigation of Sir William Ramsay the possibility of such an eventual development of other energy sources was in 1910 seriously investigated in England by a number of competent men. On that occasion the possibilities were taken into account of making use of the ocean tides, of the internal heat of the earth, of the energy of the winds and waterfalls, of the kinetic energy of the earth's rotation and of its yearly motion in space, of the chemical energy of wood and peat supplies, and finally of the intra-atomic energy of the atoms of the elements.

This official inquiry showed that the application of the internal heat of the earth, of the kinetic energy of the earth's motions, of the energy of the winds, and the use of wood and peat supplies never would be of any significance for the solution of the problem in comparison to the enormous quantities of energy yearly furnished by our resources of coal and oil. The energy that could be obtained by the disruption of the atoms of our chemical elements would be enormous in amount, but we need not further consider it at this time because in the opinion of our ablest scientists the practical accomplishment of this objective will be achieved only in the far-distant future, if ever.

The available water power on the earth would, according to Engler, amount to about the energy of seventy million tons of coal annually, i.e., to about 4 per cent of the energy necessary every year. Of course, the total water power present on earth is much greater, but an appreciable part of it will probably never be available. A calculation made in 1922 by Steinmetz seemed to indicate that the energy of the flowing water, corresponding to the yearly amount of rain in this country, would be almost equivalent to that of its yearly coal consumption. Spoehr, however, has emphasized that these calculations are totally theoretical, as a great part of that energy is inaccessible and the distribution of the remaining energy over such an extensive territory would meet with almost insurmountable difficulties. Therefore in this respect America is, for the time being, dependent in a large degree upon her own resources of coal and oil, of which the latter seems to be rapidly approaching final exhaustion, notwithstanding the apparently reassuring fact that new sources of limited extent are frequently being developed.

Energy Production From the Sea

The possible use of the low and high tides of the sea has occupied the attention of various inventors since the fifteenth century. Indeed, the periodically alternating low and high ocean tides would furnish gigantic quantities of energy if it were only possible to use them for mechanical purposes in a not too expensive and complicated way. In recent times several solutions of this problem have been proposed, some of which have already found a practical application, although only on a relatively small scale, in France, in England, and in several places in Germany (Ditmarschen, Husum, Hüll). The systems with two large communicating water reservoirs, instead of those with a single one, seem to be preferable, as they allow an uninterrupted action both day and night, even during neap tide. Their theoretical efficiency, for a difference in sea level of about three meters (10 ft.), is,

however, less than that of a system with a single tank, and is not greater than about 4800 kw. for each sea tide and for each square kilometer (12,500 kw. per square mile) of surface of the reservoirs, and in practice this efficiency is appreciably diminished by a number of uncontrollable factors, as, for example, the irregularities in the level differences of the tides, to the square of which the energy output is proportional. Such a plant would be extremely expensive and its maintenance would be very costly. Consequently it could economically be operated only under very favorable local conditions. It is therefore probable that no satisfactory solution of the problem of the production of energy in this manner is to be expected.

Recently, however, there seems to be indicated another way of energy production from the sea, which, in my opinion, may become of high significance in the future. I refer to the experiments of G. Claude and P. Boucherot upon the utilization of the relatively small but very constant temperature differences that exist throughout the year between the sun-heated surface of the tropical oceans and their deeper layers, the temperature of which is kept at from 4 to 5 deg. cent. (39 to 41 deg. fahr.) by the cold polar-sea currents. In 1913 your countryman Campbell pointed to the possibility of obtaining mechanical or electrical energy by means of these very constant temperature differences, and in 1923 Romagnoli, Dornig, and Boggia made analogous propositions. It was, however, only recently that the well-known French chemist Claude and his collaborator Boucherot succeeded in giving experimental proof of that possibility. They were able to demonstrate that a small Laval turbine designed to be driven by steam within pressure limits ranging from 20 to 0.2 atmos. (284 to 2.84 lb. per sq. in.), can advantageously be driven by water vapor with tensions between only 0.04 and 0.01 atmos. (0.568 and 0.142 lb. per sq. in.), corresponding to temperature differences between 25 and 8 deg. cent. (77 and 46 deg. fahr.) only. According to their calculations and experiments, a net output of 54,000 kg-m. could be obtained from each cubic meter of water (11,000 ft-lb. per cu. ft.) between 28 and 5 deg. cent. (82 and 41 deg. fahr.), if there be subtracted the energy that is necessary for pumping the cold and air-free water from the depth of the ocean to its surface. An installation of this kind having a capacity that effects the displacement of 1000 cubic meters (35,300 cu. ft.) of cold water every second, would be able to produce 400,290 kw. of electrical energy, this efficiency being about thirty or thirty-five times as great as that of a low- and high-tide plant of the same dimensions. In their provisional installation at Ougree-Marihaye, Claude and Boucherot recently demonstrated before a meeting of engineers that a turbine could be run by utilizing the slight temperature differences of the water of the Meuse, ranging only from 28 to 8 deg. cent. (82 to 46 deg. fahr.), and that it could drive a dynamo with a capacity of 59 kw. The calculation by Boucherot of the necessary costs of installation seem undeniably to indicate that the practical realization of this idea lies very probably within the limits of technical possibilities.

Possible More Economical Use of Present Stocks of Coal and Oil

The question as to whether it would be possible to use our present stocks of coal and oil in a more economical way than is now usually applied is of high importance and has often been the subject of discussion and investigation. In the present exploitation of our oil fields, about three-fourths of the oil remains in the soil. This needs, in the future, to be recovered by some process suitable to the purpose. Even the continuous improvement of the steam engine, or its substitution by turbine or gas motor, cannot eliminate the ominous fact that the greater part of the heat of combustion of the coal and oil will, when thus used, always be wasted. At the present time it seems that the most effective way of limiting, as far as possible, this squandering of energy consists in the combustion of the coal *in loco*, i.e., at the mines themselves, and the immediate utilization of the heat of combustion for the production of high-tension electric currents. It is possible that some way may be found for transforming the potential energy of the coal directly into electrical energy, but experiments along this line have not yet met with practical success. None of the so-called "fuel batteries" constructed for this purpose in the last decade can be considered as being adapted to practical development, because their current efficiency, even at higher temperatures, remains in each case much too small by reason of the unsatisfactory reaction velocity of the electrochemical processes going on in them.

As the matter now stands, we can say that in answering the question as to how to make the future necessary energy production most completely independent of the fossil stocks of energy accumulated in former geological periods, we are chiefly confined to the mighty current of radiant energy that is flowing to us directly and continuously from the sun. This quantity of radiant energy appears to be stupendously great, but it is now almost completely lost by dissipation. Some data may give you a clearer understanding of this fact.

Radiant Energy Received From the Sun

According to Langley's measurements of the solar constant, each square meter of the earth's surface receives, every hour, a quantity of radiant energy that is equivalent to 1800 calories (664 B.t.u. per sq. ft.). If we regard the sun as limiting herself to an eight-hour working day in tropical regions, it can be calculated that every square meter of the earth's surface daily receives from the sun's radiation a quantity of energy equivalent to the heat of combustion of 1.3 kg. (2.86 lb.) of coal. For every square kilometer this is equivalent to 1,300,000 kg. of coal (3700 tons per square mile), which means that the total annual amount of energy produced throughout the world through the combustion of coal would be equaled by the radiant energy of the sun which, during a like period, falls upon a surface of only 3300 square kilometers (1275 square miles). The desert of Sahara has a surface of about six million square kilometers (2.3 million square miles), and therefore annually receives a quantity of solar energy that is equivalent to more than 1800 times that derived from the world's total yearly consumption of coal.

Utilization of Solar Energy

At present this enormous quantity of energy is almost completely lost; only three per cent of it is absorbed and used by the living plants on the earth. Although this percentage is a very small one, the total quantity of radiant energy annually absorbed in this way over the whole solid surface of the earth still amounts to about fifteen times the yearly world consumption of coal. But the question arises as to whether and in what way it would be possible to catch the enormous quantity of solar energy that now is dissipated every year, and to apply it to the production of mechanical and electrical energy.

In the consideration of this question two points should be emphasized at the outset: first, the necessity of concentrating and accumulating the solar energy supplied to large surfaces; and second, of absorbing this solar energy to the greatest possible extent. Absorption must precede the transformation of radiant energy into those other forms in which it can be used for our immediate purposes. After absorption the solar energy may be immediately transformed into heat, which may then be utilized in the usual manner for the production of mechanical work; or the radiant energy may be absorbed by special substances in which it sets up a "photochemical" reaction and thereby

produces a certain amount of chemical energy. This chemical energy can afterward be changed into another form of energy suitable for our use. Nature has solved the latter problem of utilizing the solar energy through a most remarkable photochemical process in which that mysterious laboratory which we call the "living vegetable cell" is involved. The plant utilizes the radiant energy of the sun to synthesize a large number of complicated chemical substances in its protoplasm. These compounds accumulate in the plant organism, and their stored chemical energy can later be employed for the production of mechanical work. We also know of other photochemical reactions in which a fraction of the absorbed radiant energy is immediately transformed into electrical energy. I shall discuss these more fully later on.

Let us first consider the other and simpler case of utilizing the solar energy by first concentrating and absorbing it, and then transforming it into heat.

Concentration of the radiant energy may be effected either by means of large lenses or by a system of mirrors; the absorbent heat reservoir is placed at the focus. In actual practice, only systems of mirrors have been used. These are mounted on a light frame which permits them to be easily rotated, which is of course necessary because they must follow the apparent motion of the sun in the sky. The radiant energy concentrated by these mirrors falls upon a metallic reservoir which is blackened on the outside and which contains some volatile liquid that shows a considerable vapor tension at relatively low temperatures. Ammonia, sulphur, dioxide, or certain organic liquids of low boiling point are employed. An example of this type of installation is that devised by Schulz, in which, using sulphur dioxide, an output of about 1 hp. was obtained for each square meter of surface of the absorbed reservoir. At the ostrich farm in Pasadena they have used, and perhaps still are using, a conical aggregate of mirrors of ten meters diameter, in the focal line of which a steam boiler was placed. This developed steam at a pressure of from ten to fifteen atmospheres (142 to 213 lb. per sq. in.) after only one hour's exposure to the sun, and the device was used for pumping water at the rate of 6000 liters (1585 gal.) per minute, and for driving a dynamo.

It may be possible that in dry and tropical climates this method of utilizing solar energy may be successful on a small scale, the cost of the equipment being compensated by the fact that the expense of operation is very low. But under less favorable conditions this device can never be expected to yield a satisfactory solution of the problem because it concentrates the radiant energy that falls on only relatively small surfaces. The proposal of Claude and Boucherot offers much greater promise in this respect because it utilizes the energy that is accumulated over the immense surface of the ocean during long intervals of time.

Final Solution to Be Sought in Utilization of Specific Photochemical Reactions of Radiant Energy

These considerations lead us to the conviction that the final solution of the problem must be sought rather in the utilization of specific photochemical reactions of the radiant energy. I intentionally use the word "specific" here because experience has shown us that the action of radiation upon chemical substances is highly exclusive in character. The assimilation of carbon dioxide by plants is a well-known example. The radiation is here absolutely necessary for bringing about this reaction which goes on at ordinary temperatures, the living cell being able under the influence of sunlight and with the acid of its chlorophyll to synthesize a number of complicated substances which we in the laboratory, in spite of the high development of synthetic chemistry at the present time, are able to produce either not at all or only with great difficulty, even when high temperatures and powerful agents are employed.

We are still dependent for the production of most of our foods and drugs upon photochemical processes that proceed under the influence of solar radiation in the plant cells. Although it seems possible, according to the experiments of Ciamician and Ravenna, to influence these processes within certain limits by special external stimuli, we really as yet have little understanding of the true mechanism of these reactions. But the researches of Baly, which have shown that moist carbon dioxide may, in the presence of certain substances such as compounds of cobalt or nickel, be transformed through the influence of ultra-violet light into substances like sugar, have demonstrated that it is possible to produce in the laboratory compounds that are formed in the natural processes of the living plant. No one as yet has succeeded in carrying on this photochemical synthesis on a large scale. It offers, however, an alluring prospect because, according to Brown's investigations, if it is assumed that a quantity of solar energy equivalent to five calories will transform one liter of carbon dioxide into sugar, and if only 4 per cent of solar energy during an eight-hour day is assumed to be photochemically active, it would be possible in this manner to produce 374 pounds of sugar every day by the use of a tank having a surface of only one hundred feet square. This amount of sugar, besides its value as a nutriment, would, if used as a fuel, be equivalent to about 154 pounds of coal. It is extremely doubtful, however, whether this method of utilizing solar energy will ever be brought to practical success.

The remaining possible solution of the problem of utilizing the radiant energy of the sun for the production of mechanical work is the application of reversible photochemical reactions which proceed in such a manner that the absorbed radiant energy may be converted into a usable form such as electrical energy. If the reversibility of such photochemical reactions is nearly quantitative in character, the photosensitive system of substances will then, in respect to solar radiation, play a role analogous to that of the lead accumulator in respect to electric energy. We might term such instruments "radiation accumulators;" they would be exposed during the day to the solar radiation which would cause a certain photochemical reaction, and then at night when left in the dark this reaction would reverse, the materials would return to their original condition, and the radiant energy absorbed during the day would be set free and stored up for mechanical uses.

It has long been known that such reversible photochemical processes really exist. For example, if a solution of mercuric chloride and ferrous chloride in water is exposed to light radiation, a reaction takes place in which certain amounts of mercurous chloride and ferric chloride are formed, a chemical equilibrium between the four salts being finally reached. If now this solution is placed in the dark, the substances will revert to their original form, and during this inverse reaction the radiant energy absorbed will be completely set free in the form of electrical energy. It is possible to obtain a tension of 0.17 volt by means of such a photochemical cell; consequently a dozen such cells joined in series will yield the current furnished by an ordinary lead accumulator.

Again, such a photochemical cell can be made by placing two platinum electrodes in an acidulated solution that contains potassium iodide and ferric chloride. When this cell stands in the dark, ferrous chloride and a certain amount of free iodine will be formed, the iodine remaining dissolved in the excess of potassium iodide. On exposing this cell to the action of light, the chemical equilibrium is displaced in the opposite direction, and potassium iodide and ferric chloride are regenerated. The absorbed radiant energy is set free as electric energy.

Another remarkable example of a phenomenon of this nature is described by Rigollot. Two plates of red copper, each of them superficially covered with a thin layer of cuprous oxide, are placed in a saturated solution of sodium chloride. If now one of these plates is exposed to light radiation and the other is kept in the dark, an electric current passes through the wire that connects the two electrodes. This current continues as long as the exposure lasts. The whole system returns to its original state in the dark. If the other electrode is illuminated, the electric current produced in the circuit flows in the opposite direction.

These various experiments furnish definite proof that it is possible to convert radiant energy into electrical energy by means of reversible photochemical processes.

There is, however, one great drawback to the practical application of such a method, and that is the very low intensity of the electrical current that is produced. The electrical work that can be done, which is a product of the voltage and current intensity, is therefore in all cases only extremely small. The explanation lies in the fact that the reversible transformations which take place in these cells are characterized by very small reaction velocities, and consequently the energy that is carried off cannot be resupplied by the photochemical reactions with sufficient rapidity. The photochemical effect appears in general to be the strongest in those cases of reversible processes in which the oppositely directed reactions are slowest, and because of this fact some investigators are inclined to doubt whether the utilization of such radiation accumulators can ever be of practical value. This opinion may, however, prove to be unduly pessimistic. The construction of such cells is wholly a problem of reaction kinetics. If it should prove possible to devise radiation accumulators or Volta cells in which reversible and very rapid photochemical changes take place when radiation of such wave lengths as are contained within the solar spectrum is employed, the problem of using solar radiation as a source of energy might be regarded as definitely solved.

We are, however, still far distant from this goal. Photochemistry is still in its infancy and it has not yet outgrown the stage of mere empiricism. It is quite possible, however, that when man's existence becomes seriously menaced because of a shortage of energy, photochemistry will rescue him from his distress.

The protection of mankind from this danger rests chiefly upon the physicist and the chemist, and they must ever be on the alert to find solutions for these intricate problems that involve the very existence of our race.

European System for Technical Education Has Potential Field in America

A paper by W. E. Wickenden, director of investigation, S.P.E.E. and president-elect, Case School of Applied Science, was published in the June issue of Mechanical Engineering. This gave a comparison of American and European methods of conducting technical education, and developed the theory that the European feature of a technical institute could be developed and be applied in the United States to advantage.

The technical institute is a non-university type of school above the age level of the secondary school, whose courses are for young men already in active contact with industry, and who wish specific preparation for advancement. Mr. Wickenden investigated schools of this type in France, Great Britain, and Germany, and recommended their use in the United States together with the establishment of some form of national certification.

When the paper was presented at the Rochester meeting of the A.S.M.E., there was considerable discussion. Some of this has been submitted in writing and is abstracted in the following pages.

JOHN T. FAIG.[1] Education has developed according to a very simple plan in this country. Most of our citizens recognize the eight years of the grammar school as a primary school, the four years thereafter as a high school, and the four years following these as undergraduate work in college. Anything different from this simple set-up confuses them. If Dr. Wickenden had represented this simple set-up in a fourth figure similar to Figs. 1, 2, and 3, in his paper, the simplicity of our educational scheme as compared with those of France, England, and Germany would have been very striking.

There are a number of institutions in this country that cover part of the training recognized by Dr. Wickenden as belonging in the technical-institute field. These are hardly sufficient in number to establish the type, and from time to time pressure develops in one or another of these schools tending toward conformity with our simple educational set-up. There have been schools in this field that have yielded to such pressure, which may come from the graduates, or from the faculty, or from the trustees, with the result that these institutions have become four-year engineering colleges. This has occurred in localities where the purpose of the engineering college seemed to be adequately served by existing engineering colleges, and where there appeared to be a real need for technical institutes. In view of the conclusions in this paper, such action appears to be of doubtful wisdom. It would seem wise to conserve our institutions in this field and give them encouragement.

R. L. Sackett.[2] Germany, France, England, and Scandinavia have been more democratic than the United States in providing graduated instruction preparatory to various levels of industrial occupation. This country, though a democracy, has devoted more energy to the development of the university and the arts college than to polytechnical education. Undoubtedly a stratum of society has been neglected to our industrial detriment. Vestibule training, apprentice, and graduate apprentice courses have been developed within industry in this country though they are not absent from Europe. The General Motors School at Flint, Michigan, is probably in some measure a result of our failure to provide adequately for this intermediate type of training. One might ask if industry should not be left to train its employees as it sees fit. The small industries cannot set up a school and carry the overhead. Furthermore, the continuation school, which is an essential part of such an educational program, has already been approved and there are numerous pre-occupation courses in our school systems in one form or another.

It seems clear that future success in industrial competition

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[2] Dean, The School of Engineering, Pennsylvania State College, State College, Pa. Mem. A.S.M.E.

will depend to a degree on the breadth and soundness of occupational education, and this requires some form of technology which is not now provided in sufficient variety and distributed widely enough to meet the needs. There are excellent examples of such schools, but a system developed under a national policy is needed.

John D. Ball.[3] There seems to be a general opinion that there are two general forms of technical schools. The university, or college type, and the technical institute described by Dr. Wickenden. There is also a great opportunity for an additional type which combines the desirable elements of both the college type and the technical institute. Such a school would operate its first year largely as a technical institute, adding thereto mathematics of a college type. Its second and third years would be of a nature to supply technically trained men of a higher grade and, at the same time, to offer more studies of a college type, and devote attention to cultural studies and indirect moral training. The fourth year should be more highly technical than can be offered by the college type, as the student has a three years' background of practical as well as theoretical training. Hence he may interpret theory through his own experiences. The School of Engineering of Milwaukee is so organized, and the achievements of its graduates have justified such an arrangement.

Such a plan deviates slightly from that proposed of Dr. Wickenden, in that:

1 It is adapted to the needs of recent high-school graduates as well as to those already employed in industry.

2 It has definitely revived a "bookmindedness" in many cases where absence from school has caused this trait to become dormant.

3 The student whose potentialities or means are not fitted for the college courses may progress as far as his individual ability or means may permit. If he does not complete the entire course, he has the advantages of the "technical institute."

4 The student whose potentialities or means make a complete college course desirable has the chance to continue his work and obtain his degree. In many cases of latent development, the student is initially better fitted for the "technical institute" than for the college, but should his development warrant full college training, the opportunity is offered, whereas, at present, the standard college is not organized to fit his situation.

Allan R. Cullimore.[4] The writer believes that, as quoted by Mr. Wickenden, Huxley's ideal of a technical education is sound for America as well as for Europe. "A ladder reaching from the gutter to the university upon which every youth may climb as far as his ability may take him," certainly expresses definitely the ideal of technical education. From a study of technical education both in Europe and America the writer must, however, conclude that this ideal has not been reached either there or here and that it is impossible to reach it with a system of parallel ladders. Further than this, the writer believes that such a system of parallel ladders may meet the situation in Europe but cannot meet the situation in America unless subjected to modification.

Mr. Wickenden states, "It is well to recognize that the differing educational forms abroad follow planes of social cleavage which we do not wish to reproduce." This the writer believes to be exactly true, but is it exactly true that, as Mr. Wickenden says, "Their merits stand largely apart from those incidental considerations, and may be found to be in no sense incompatible with American ideals of democracy."

Following the simile of parallel ladders, these ladders, abroad, extend vertically from classes bounded by different social lines. The ladders leading from these particular classes or social groups extend to different heights, and if a man is to reach the top of the very highest ladder, that is, the one leading to the university, there must be a possible means of traveling across between ladders. It would seem that if Huxley's definition is adopted, and there is more than one ladder, there must be provided at different levels a very definite method of getting across from the vocational ladder, if you please, to the technical-institute ladder, and from the technical-institute ladder to the university ladder. It must be made possible to transfer from one particular ladder to another leading higher. The writer believes this to be a fundamental factor in the building up of a system such as Mr. Wickenden proposes.

In considering the growth of the college, and particularly the engineering college in this country, one should consider that both have prospered because they did furnish a ladder from the gutter directly to the university. Without definite class lines there has been no tendency to shut off entrance from the bottom of this university ladder as has been the case in Europe. The writer is of the opinion that the development of the technical college has come about because of these conditions rather than because of strictly historic reasons. As a practical factor in building up an educational system, it is certainly of first importance. It is perfectly possible in England and on the continent to build up a system of parallel ladders consisting of any number of such pathways, each footing in a definite social group or class, and it is not perhaps a prime necessity in these countries that there should be a frequent possibility for a young man to climb definitely a little further along a ladder which does not foot in his own class. In America such a situation, the writer believes, could not exist.

Mr. Wickenden mentions the transfer from some of the lower forms of vocational education to some of the higher forms in Scotland. This same principle should be applied throughout the whole scheme or plan of technical education and the system should provide, and must provide, the writer believes, for a transfer so that any boy on any ladder heading toward any objective or terminal level shall have the privilege, providing his ability warrants it, to transfer to another ladder leading higher. This is at present one of the greatest handicaps in the development of our American technical educational system. An attempt is now made in our high schools at a very early age definitely to fix objectives and to establish terminal levels, and while such a practice may seem to accomplish results, it is extremely doubtful whether a terminal fixed for a young boy of fourteen can be sound.

To those of us who have had a considerable direct connection with schools of the technical-institute type and the college type the realization comes that the greatest trouble is with young men who have had industrial and so-called technical-institute training, but who, when they consider the college or university, must either climb back down the ladder and climb the university ladder from the foot or at least back down a considerable distance before they can go over.

Mr. Wickenden's conclusions regarding the difficulty of interesting young men who have taken college work in supervising and operating positions are perfectly sound and true, and what he says concerning the majority of young men with industrial experience is likewise true, but the fact remains that there are many young men who come up through some considerable industrial and technical-institute experience who would make intellectual leaders. Perhaps the number and percentage of

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[4] Director, Newark College of Engineering, Newark, N. J.

these men are particularly small if they are evaluated as individuals. In evaluating them, however, from the standpoint of their ultimate worth to industry, it would pay to save even a small percentage of those men who come up through the ranks who have real intellect and real capacity for leadership.

In an experience with these two allied types of work over the past ten years, the conclusion has been brought home that the reasons for the choosing of a ladder other than the university one have been in this country purely economic ones, and for those reasons alone, and the writer has seen no cause to believe that there was any correlation between a man's economic status and his intellectual status. Practically also it is proving almost impossible in America to recruit young men from the technical-institute type of work unless they are recruited at night. This is of course again due to the economic situation. The average parent does not care to indicate to his son a ladder reaching to an objective no matter how definite unless he can see that from this ladder he can change to another one which leads higher.

If there are a series of parallel ladders reaching to definite levels, and if there are no obstacles in the way of mounting to any one of these ladders, it is questionable as to the number in America who will choose the shorter ladder. For many years the idea has been fostered that the educational system provides a continuous progress from the bottom to the top, and to provide a second ladder without communication would seem questionable. A series of parallel ladders, therefore, unless these intercommunicate, are less consistent with American ideals than with foreign ideals. I seriously doubt whether it is possible with us here to erect any system of technical education unless it can be definitely shown that all ladders may lead ultimately to the very highest possible point. I am well aware that a transfer from one ladder to another is in practice extremely difficult. It is not, however, impossible.

I have been particularly interested in this phase of the situation for a number of years and experience would indicate that separate ladders with different terminal levels, more flexible as to entrance and exit, are very much to be desired, and that it is perfectly possible to take a young man from one of these termini, or at least without too much loss, across to another level which reaches somewhat higher. Practically speaking we see the same situation with respect to our vocational schools, some of our technical institutes, and our colleges. A young man may go to a vocational school and start to climb the ladder with a very definite fixed terminal. When he reaches there it may seem extremely desirable for him to attempt some work of the technical-institute type. There are each year many young men who desire to make this change. It can only be done at present by backing down the ladder several rounds and insisting on certain subjects, notably in science and mathematics, which he should have but which the vocational school does not offer. After he follows out the technical-institute ladder and proves himself to be somewhat exceptional and desirous of going ahead, and wishes to step across on to the college or university ladder, it is impossible to do this unless he backs down many more steps and takes up certain studies which are considered fundamental for matriculation if a man is to take general university work.

It seems in studying the situation, particularly in Great Britain, that this is the fundamental lack in the whole plan. Twenty years ago this lack was not apparent, but with the present trend of democratic ideals it is becoming more apparent even abroad; and any system which is built up here should be modified in the light of that particular experience. I am firm in the belief that a system of parallel ladders, with definite terminal levels and with a machinery for transfer between ladders, and further machinery for the carrying of young men only so far as their ability warrants, is perfectly feasible and may be worked out in this country.

It is not hard to imagine machinery which could at any particular level either transfer a man to another ladder or shunt him on a terminal platform. In fact, that is done every day by means of written evidence which is called examination. There is no reason why there should not be a continuous path from the bottom to the top. There is no reason why men should not be shunted off at various levels after having completed a course preparing them to work on this level, and there is no reason why a young man who shows at that level ability to proceed to another ladder should not do so. If this is done we shall secure all the advantages of the systems abroad and shall add a factor which must become increasingly evident in Europe as well as in America. The ladder must extend from the gutter to the university and in going from the gutter to the university a young man of real promise and real intellectual ability cannot be asked to climb the vocational ladder, climb down again, climb the technical-institute ladder, climb down again, and climb the university ladder to the top. This is not consistent with our particular democratic ideals of education.

Charles R. Allen.[5] The most striking thing in Mr. Wickenden's paper is the evidence of a situation abroad which is recognized there, but which has not been recognized in this country. This situation is due to the fact that there exist lines of promotion reaching in many cases to important positions which, for one reason or another, are not followed satisfactorily by the graduates of engineering colleges. This fact, if true, indicates the need in this country of institutions of a character similar to those which are described in Mr. Wickenden's paper.

The writer has been for a long time of the opinion that the multiplicity of courses for professional training in engineering was not only tending to overcrowd the engineering professions, but that this situation gave an unbalanced program in that corresponding provisions were not being made for the training of supervisors and technicians in industry.

A second thing which strikes me in this paper is the emphasis which the author lays upon the necessity for selection. That is now recognized as a fundamental principle in all forms of vocational education. I can not altogether agree with Mr. Wickenden in his apparent conclusion, as I understand it, that those who are squeezed out of the engineering course would necessarily make good material for institutions of the type with which his paper deals. They might or might not, but it is probably true that in the training of supervisors and technicians on a level below that of the college and above that of the trade school, a similar selective process would have to be applied. It is to be hoped that this will be done with more efficiency and less waste than has been true in the past in the engineering college.

The writer endorses the author's opinion that a much larger proportion of the higher technical personnel should be recruited from men who have already had normal and industrial experience. All are beginning to realize very keenly that the ability of an individual to carry on any form of organized work depends very largely upon the experience base which he has secured. Unquestionably one of the difficulties experienced by the engineering colleges has been the degree to which young men, perfectly green with regard to actual industrial experience, have been pushed through their courses. This situation has been recognized by some of the engineering colleges, who have established what might be called part-time arrangements.

It also seems that the method of national credentials, as

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described by Mr. Wickenden, represents a very important factor in any plan which may be worked out in this country. Possibly the only organization in this country, which could provide such credentials, would be an organization similar to The American Society of Mechanical Engineers.

Another important point is the emphasis laid in Germany on the amount of experience required for teachers in these secondary technical schools. A similar situation ought to be brought about in this country. The opinion expressed that professional and intensive forms of technical education can not be maintained in equilibrium in the same institution has been fully justified by the experience in this country on vocational education of less than college grade.

Charles W. Morey.[6] It cannot be pointed out too often that the field of the technical institute is not the same as that of the university. Students of the former are usually young men who, for various reasons, cannot attend a university, and having had some previous practical experience, desire specialized and intensive training along the lines in which they are interested. Courses, therefore, must be shorter and more directly technical than in the universities.

The technical institute should provide terminal courses of training which do not require four years or more of preparation. It has been demonstrated that four-month, one-, two-, and three-year courses in subjects such as surveying, machine and tool design, building construction, quantity surveying, power-plant operation, and the like, are very effective in training young men for the higher practical posts in industries.

The question of entrance requirements must be approached from a different angle than in the universities and, as Dr. Wickenden ably concludes, students should be admitted on evidence of capacity, experience, and interest, rather than on formal academic credentials. The method used in France where a highly selective plan of admission is in force, would not, in the writer's judgment, be desirable in the United States, where it is hoped that every boy may have unrestricted opportunity. Besides, this plan would scarcely provide enough technically trained men for the industries in this country.

From the data given in this paper concerning both French and English technical schools, it would seem that the full-day colleges lean somewhat toward university studies and ideas. This, in itself, is good if not carried too far. There is always a tendency, under cover of "raising the standard of instruction," to enter the field occupied by the universities, and thus defeat the purpose for which the technical institute was organized.

This country may well profit by Great Britain's experience in giving evening technical instruction. For maximum efficiency, classes should not meet more than three evenings per week for twenty-five to thirty weeks, otherwise the student becomes listless and too tired. Class sessions of two hours each allow the student to absorb or digest readily the subject matter. A great deal of home work cannot be expected from the student, which, therefore, requires that the instructor be patient, and in order to keep the interest, make the instruction practical and very direct. Evening classes may contain from twenty to twenty-five students for each instructor.

Dr. Wickenden's observations abroad concerning mixed types of courses in the same institution resulting eventually in a drift toward university methods, where the situation is dominated by a group of professional teachers, confirms the writer's experience and belief that great care must be used in choosing the men who give instruction in technical schools. As the aims and ideas of the students in these schools are different from those of students in the universities, the teacher must adapt himself to his surroundings. He must be less theoretical, and if he can bring to his students a sympathetic attitude resulting from actual practical experience in addition to theoretical training, he will be highly successful.

In connection with Dr. Wickenden's conclusion that the non-university technical schools should meet the needs peculiar to local populations and local industries and leave to the universities the more universal subjects, the writer has found at least one great industry, that of building construction, to be a very important field for the specialized instruction offered by the technical institute.

It is doubtless important, as Dr. Wickenden concludes, to establish some form of nationally recognized credentials other than academic degrees. There is some question in the mind of the writer as to whether the British practice of awarding national diplomas and certificates would be entirely successful in this country. To avoid anything in the nature of political influence he suggests a plan of national recognition sponsored by the national engineering societies in cooperation with representative employers in the various engineering fields. This plan would tend to unite more closely industry and education and, at the same time, acquaint employers with the sources of supply of technically trained men.

However, for the technical institute to hold true to its distinctive function, the German method of having the technical universities and institutes under separate control is highly desirable.

J. M. Spitzglass.[7] Impressions, received from a year recently spent in Europe by the writer, indicate that the German-trained or so-called educated man is better acquainted with fundamentals than the corresponding technical man in the United States. The reason for this is the reward obtained. A better job is obtained through the title obtained in school, and as the school requires a knowledge of fundamentals, hence the result. While the German student is not a book-minded man, the schools seem to inject into him the necessary fundamentals. This should be impressed on successful business men so that when they have jobs to be filled they will look for fundamentals and changes in school curriculum.

Another important item lacked in this country is authority. A ministry of education is lacking. By authority is meant the responsibility and consideration of reward to the one who is deserving. It works for the success of the industry.

The pertinent fact to be noted by those who administer educational medicine to the future engineer is that probably three-quarters of these men will eventually be called upon to direct the work of other men—but that they will reach these positions *only* by traversing the hard road of technical effectiveness and will be asked to direct *only* because they have demonstrated a profound grasp of the work to be done.

Engineers are not generally selected as administrators *per se*, but because our industrial machine is so complex in its technical relations that none but an engineer can see how the wheels go around. Boards of directors have acquired a wholesome fear of the damage that may result if the control of this mechanism is left too much in the hands of the man who is simply a natural leader and who does not understand the technical aspects of the job. So they turn over to the engineer most of the staff positions of industry, hoping and praying that he will possess or acquire enough general managerial sense to handle the human and financial aspects of his job. *Power*, July 30, 1929, p. 171.

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[7] Vice-President, Republic Flow Meters Co., Chicago, Ill. Mem. A.S.M.E.

The Duties of a Chief Executive in a Business of Moderate Size

By WM. L. BATT,[1] NEW YORK, N. Y.

The author visualizes the functions of a chief executive of a modern corporation as:

1 The creation of an effective operating staff, which involves the definite division and allocation of junior executive responsibility and the maintenance of an esprit de corps;

2 The correlation of income and disbursement ordinarily through the medium of the so-called budget; and

3 The determination of major policies and the study of trend of development of the business both in its relation to competition and to general conditions.

The paper discusses these duties of the head of a corporation of moderate size and attempts to evaluate their relative importance.

THE use of the term "organization" as applied to the corporation is of comparatively recent origin. It doubtless has its inception in the changed viewpoint which has characterized the machinery of business of the last one or two generations. This has been a most significant change, and the results are so far-reaching that only coming years will be able truly to evaluate them. The old paternalistic theory of business operations wherein one, or at most a few, individuals dominated every act of a business, has given way to the conclusion that it pays to encourage each individual of the entire operating force to carry some definite share of responsibility. The very large units have made this method of operation imperative; the smaller ones have found it no less desirable. And, for the obvious reason that only in that way can the sum total of all the knowledge and experience of a group of persons engaged in a common object be most completely translated into the only common denominator that business knows—namely, net profits.

One outstanding effect of this development in the business structure has been to assign definite and specific responsibilities to the chief executive. As contrasted with the old system of operation wherein he was not only theoretically but, to a greater or lesser extent, actually in touch with every detail of operation, he now functions specifically in certain definite directions. Each executive will desire to formulate for himself his relation to his own business in the light of its particular problems. But it is quite certain that he will, more than ever before, definitely delegate authority and responsibility as far as his organization has been trained to accept it. A measure of his success in creating a properly functioning organization will be the extent to which all routine details of operation can be assumed by others. Only in that way will he be enabled to keep himself free to assume those functions which are peculiarly his own.

Functions Peculiarly Those of a Chief Executive

Broadly the author has visualized these as:

1 The creation of an effective operating staff, which involves the definite division and allocation of junior executive responsibility, and the maintenance of an esprit de corps;

2 The correlation of income and disbursement, ordinarily through the medium of the so-called budget; and

3 The determination of major policies and the study of trends of development of the business both in its relation to competition and to general conditions.

It is proposed to discuss in this paper these duties of the head of a corporation of moderate size and to attempt to evaluate their relative importance.

An executive of a business of such size has many opportunities that do not exist for the heads of the very large aggregations of capital. The most outstanding of these is that a unit of moderate size is large enough to permit the building of an adequate executive operating structure, and yet not so large that its head may not have a moderately close personal contact with all parts of it.

It is obviously impossible to define precisely the term "moderate" as applying to the size of the organization whose executive problems are to be discussed. The usual conception of moderate size in the United States, or even in a single industry in this country, may well differ widely from that of another country or another industry. In the author's mind, the company with which he has been associated for many years may fairly be termed of moderate size. It has something less than twenty-five hundred employees, manufactures its products in three plants, and distributes them through a network of direct sales branches located in the principal cities of the country. It has a capital investment of approximately $20,000,000, and a sales volume adequately corresponding thereto. It is therefore small enough to admit of a reasonably intimate executive contact, and yet of sufficient size to require a detailed division of executive responsibility.

What are the duties of the chief executive of such a company? In the attempt to answer this question precisely, differences in executive viewpoint are quickly disclosed. The accepted method of executive control of a generation ago still prevails in many parts of the world. Its basic premise is that, whatever the size of the undertaking, the head must, in so far as his time and strength permit, make all decisions; he must know as much about the detail of the business as is humanly possible. By accepted tradition he will regard such matters as signing checks, personally supervising the opening of the mail, and the signing of at least all important letters with his own signature as essentials requiring his own personal participation. And it is obvious that this requirement, for the chief executive to be in touch with every question, need not necessarily arise out of a desire for personal prestige. It is consistent with a sense of executive responsibility that knew no other method of operation.

The modern American theory of executive operation is of course essentially different. The author finds it impossible, in the application of this theory, to distinguish any difference in the principle due alone to the size of the organization. He is of the opinion that, once he has his own conception of his executive responsibility clearly determined, the head of any business, whether large or small, will apply it in about the same fashion.

Duties of Executive Flow Out of His Conception of His Relation to the Business

It is the author's theory that, if the chief executive will definitely analyze for himself what his own relation to his organization is to be, the duties which are to be particularly his will flow naturally out of his conception of his relation to his business.

Of course, the successful head of a business will first and foremost be *himself*. He cannot continuously live with his organiza-

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tion and undergo its daily scrutiny, friendly or unfriendly, without revealing his real purposes. Too many men make the mistake of thinking that they are able to fool their associates merely because of their own positions of authority.

The measure of cooperation which the executive actually receives will be precisely in proportion to that which he gives. The day of the domineering type of management has passed, if for no other reason than because the modern call for efficiency has shown the enormously greater results to be had from cooperation. And incidentally this type of management will be far more gratifying and enjoyable to all concerned.

The head of a business must either hold the affection of his associates through admiration for his personal qualities, or command their respect by his recognized ability. The latter trait is much the more usual, but it is to be doubted if it is apt to make for the more striking successes in leadership. The really great business genius is that unusual man who can, on the one hand, by the sheer force of personal affection and inspiration spur his associates to accomplishments ordinarily beyond them; and on the other, through his clear and incisive ability to get at the root of any problem, command their ungrudging admiration and respect. Doubtless one of the reasons that the average business is of only moderate size is to be found in the fact that the average business leader is of only moderate ability.

To liken an organization to a team may partake of the trite. And yet no better simile can be found, for much of its attractiveness lies in its understandableness to men. It requires no proof to say that teamwork can succeed where the individual will fail; that a group of average players *or workers* animated by a common and intelligent willingness will ordinarily outrank a group of so-called stars where each is looking toward his own aggrandizement. Even the youngest errand boy knows that the successful ball team will be successful only just so long as there is a hearty team spirit. And one may be sure that he will expect the team manager to maintain and develop that spirit.

The author conceives this responsibility to be the major one facing the chief of any business, whatever its size. And it cannot be developed under a one-man policy. The executive who insists on being the "whole show," who must be consulted on all matters large and small, is definitely limiting the growth of his organization. He must permit his assistants, in so far as is possible, to exercise the utmost of individual judgment.

Delegation of Executive Authority Conducive to Independent Organization Thinking

The generous delegation of executive authority will encourage independent organization thinking. It is vital to the success of such a principle of operation that the chief executive shall unfailingly stand behind his assistants in the decisions they have made. Whether or not he agrees with the things which have been done, it is imperative in the maintenance of organization spirit that their prestige shall not be affected before their associates or the public. Suggestions for a better course for the future will always be kindly but privately made.

It is the author's firm belief that, in an organization of the size under discussion, and to a continuously greater extent in larger units, the quality of its performance will be only as good as that of its junior executives. The volume of detail and the variety of public contacts, both buying and selling, are too great for the chief to do more than formulate principles and set the tone of the group thinking. It is natural for him to attempt to do more, particularly where he may have grown up with the business and possesses detailed and intimate knowledge of the ramifications of its problems. It will be essential that he guard himself against this tendency.

It is usually forgotten that the head of a business is in a particularly difficult personal position. He is the only one in the organization whose detailed acts are not readily subject to frank criticism, from which he may benefit. The board of directors will judge him, generally by the results of the company's activities, and usually from a financial viewpoint only. In the very nature of things it is highly improbable that he will have the benefit of any considerable frank or unbiased discussion of his business habits. Fortunate is that executive whose associates are so closely bound to him by ties of mutual respect and affection that he can know what they are actually thinking. In the author's opinion this is the ideal of management, and he believes it is the more readily approachable in the moderate-sized organization than in those of larger size.

The real measure of an efficient executive is not easy of definition or determination. . . . . In any organization capably headed, one may at least be sure to find it an efficiently functioning unit; it will be able to run well without its chief for reasonable periods; it will lose and add new men without noticeable strain or stress; it will meet its business problems intelligently and fearlessly; it will act as a unit instead of as a group of individuals in more or less unrelated efforts, and its general tendency will be forward. Such an organization will not, for long, move backward. This is the measure of a good chief executive, that he shall have created and maintained such an organization.

It may be noted that thus far little has been said about the actual duties of the chief executive. That is solely because the author concludes that it is not of material significance to what particular part of the operating detail the executive gives the most of his attention, provided only that he has these fundamental principles of executive control in operation. His own training and experience, as well as the particular problems of the business, will determine the departments to which he will give the greatest attention. It is doubtless inevitable that the man who has risen through the ranks of production will, although perhaps unintentionally, show more interest in production problems. At the same time, due to his lesser familiarity with sales problems, it is probable that he will have developed stronger sales executives, and that the sales end of the business will actually require less of his attention. Nor does the author think there can be any uniformity as to the ways and means by which the executive will keep in touch with the results of the whole business. It has not been the author's observation that he has needed to concern himself particularly with the development of methods of checking up on operations or, in other words, on the work of the organization. Given the proper spirit—given a group of executives earnestly cooperating with their chief for the good of the business, and they will be anxious to see that he is kept informed as to the progress of the work for which they are responsible. From them will voluntarily come more information in the form of reports, data, and what not than he can actually use; and it will be for him rather to indicate that which he finds to be of the greatest interest and value.

Recruiting New Executive Material

One of the real problems which every executive has to face is that of recruiting new executive material. Two basic solutions are obviously available: the one lies in the bringing in of trained

personnel from the outside—frequently from similar or even competitive lines of business; the other through the definite policy of promotion of men from lower ranks. If the rate of organization growth does not call for executives at a faster rate than they can be trained, the author strongly prefers this policy. It encourages men to attempt constantly to improve the quality of their work and to strive to fit themselves for advanced positions. It most certainly tends to keep employee turnover at a minimum, and produces a more smoothly functioning group of workers. Against it may be urged its outstanding disadvantage, that it tends to create lesser originality and decreased inventiveness of thought and policy. To some extent the type of business objective will indicate the relative weight to be allowed to these advantages and disadvantages. When conditions make it necessary to bring in new men from the outside, the outstanding responsibility of the chief executive will be to fit these men properly into the organization. He must "sell" them the scheme of coordination; at the same time he must sell them to their associates, that they may smoothly and efficiently apply their efforts in a positive direction. One of the greatest obstacles in many businesses arises out of the needless friction between individual executives. This may come from either ignorance or selfishness. The head of the business will find his first duty in its eradication.

Well-Established Accounting and Statistical Department Essential to Correct Functioning of a Budget Plan

It is almost needless to say that a well-established accounting and statistical department is a vital force in every properly organized business. Such a department is essential to the correct functioning of a budget plan. The setting up and carrying out of a plan of budget operation affords an excellent test of organization functioning. The general principles of operation under a budget are too familiar to require detailed repetition. The part that the chief executive can most wisely play in the operation of such a plan may, however, be considered. As a first step in its installation, the chief executive will determine the standards which he desires reached for the period under consideration. It will be his responsibility to establish generally what he believes to be a proper sales or manufacturing quota, the permissible percentages of the various items of expense, and the final net-profit goal. This skeleton structure will have been prepared with the aid of a budget director. If the head of the accounting department is all that he can be, he will be of invaluable assistance to the chief executive as well as to the entire executive organization. He will frequently be found the most available individual to head the budget department, and the resulting data in his hands can be of inestimable value. It is literally impossible, and certainly unwise, to define the many directions which the activities of such a junior executive may well take. More perhaps than any other single individual in the organization, such a man may grow and develop out of a broad executive policy.

In the unit of moderate size it will be feasible to constitute the entire first line of junior executives as a budget committee. As a group they will be enabled to visualize the broader problems of operation and encouraged to a far closer cooperation between their respective departments than is readily obtainable otherwise.

The details of department income and expense will usually be determined between the budget director and the head of the department in question. The results upon which they have agreed will be accumulated into a total and passed upon by the budget committee. The author cannot too strongly emphasize the great potential value in such discussions. More clearly than by any other method they can be made to focus the best thought of the executive group on the problems of the business.

Real Measure of an Efficient Chief Executive Difficult to Determine

The real measure of an efficient chief executive is not easy of definition or determination. His success will, of course, be measured from two opposite angles: the first is the financial return which is earned for the stockholders, and the general enhancement of the company's position. Obviously it will require some other proof of his success if a reasonable financial return is not made to those who have entrusted their capital to his care. But financial returns can hardly be considered the entire measure of the real success of the head of a business. One need not be radical to give considerable measure of weight to the sort of business life which the chief executive has made possible for all those working under him.

In any organization capably headed, one may at least be sure to find it an efficiently functioning unit; it will be able to run well without its chief for reasonable periods; it will lose and add new men without noticeable strain or stress; it will meet its business problems intelligently and fearlessly; it will act as a unit instead of as a group of individuals in more or less unrelated efforts, and its general tendency will be forward. Such an organization will not, for long, move backward.

This is the measure of a good chief executive, that he shall have created and maintained such an organization.

Continuity of Income

Manifestly the employer and the employee have a common interest in the stability of the employing enterprise. Here is the common ground on which the two supposedly opposing forces can and should meet and cooperate. The responsibility, however, is on management. No amount of employee good-will and cooperation will compensate for the blunders of stupid business management.

Much is said about stabilization of industrial employment by smoothing out the peaks and valleys of economic progression. Doubtless with greater experience and foresight something can be done but it is not now apparent how such fluctuations can be entirely removed. Their sharp severity can and should be softened but a moderate periodicity may be more beneficial than otherwise. It surely makes for more conservative financial management and definitely affords a healthy prophylaxis of working forces.

Sickness and accident disability as the most serious source of discontinuity of income to the worker has been successfully attacked.

By careful study of mechanical preventives, and what is more important, patient and continuous education of workers in their own interest, accidents in manufacturing and railroad transportation industries have been reduced in severity and frequency more than fifty per cent in twenty years. It can be truthfully said that in the average factory environment today a worker is much safer from accident than on the street or in his own home.

The provision of healthful working environment has been one of the outstanding characteristics of industrial management in the past two decades. The wise ones have not been forced by legislation. The foolish ones nowadays pay the price in their inability to attract the good workers of the community into their factories.

The law has admittedly forced the correction of some of the worst conditions, but it has signally failed to enforce a high standard of factory sanitation. Far-sighted employers have done that. From "Basic Principles and Trends in Personnel Administration," by F. W. Willard, Personnel Director, Western Electric Company, Inc.

The Survey of the Tennessee River System by the Corps of Engineers, U. S. A.

Particulars Regarding the Recently Completed Survey of the Tennessee River Basin for Navigation, Flood Control, and Power Development—Annual Output of 25 Billion Kilowatt-Hours Possible, of Which 80 Per Cent Would Be Hydroelectric Power

By J. A. SWITZER,[1] KNOXVILLE, TENN.

THE Corps of Engineers, U. S. A., has just completed a survey of the Tennessee River Basin for navigation, flood control, and power development. Probably no like survey has ever been made in this country or in any other country. The survey, begun in 1922, has been made by direction of Congress, and has cost to date something over a million dollars. It was begun under Major Harold C. Fiske, and has been completed under the direction of Major Lewis H. Watkins.

A partial report on the survey was made to Congress in February, 1928, and was printed as House Document No. 185, 70th Congress, 1st Session. But though the printed report comprises some 230 pages, the voluminous maps, charts, plans, diagrams, and tabulations have not been published, but can be obtained in blueprint form. These blueprints comprise a folio of 345 pages, 27 × 40 in., and weighing more than 60 lb.

The survey and report constitute an important work. A coordinated scheme of water-power development comprising 141 separate power projects within the Tennessee Basin—if all of them are commercially feasible projects—is a scheme so vast as to be quite astounding; and the reality of the existence of so enormous a pool of power as the report reveals will be received with skepticism.

The topographic survey itself was a big job. The basis of the survey was airplane photography; and the airplane photographs, corrected for parallax, were used on the plane table. The extent of the survey may be seen from the fact that in its making 15,650 square miles of area were photographed from the air; and the area mapped contains 5800 square miles. Two thousand, two hundred miles of control levels were carried. Contours up to points 200 ft. or more above the river levels, where required by the survey, are plotted, with contour intervals of 5 and 10 ft. The topographic map and the river profiles occupy 388 sheets, each 27 × 40 in., and the accuracy of mapping is of a high order.

The principal streams of the Upper Tennessee Basin—the Hiwassee, the Ocoee, the Little Tennessee, the French Broad, the Big Pigeon, the Nolichucky, the Holston, the Clinch, and the Powell—have their sources at high elevations in the Southern Appalachian chain of mountains, and they drain a region of high average rainfall. On the Tennessee River itself, as well as on the numerous tributaries, good power sites are abundant. Yet only through the agency of a thoroughgoing survey would it have been possible to work out the coordinated plans for power development of the entire river system which the report contains. The total available power, according to the report, is large beyond any previous estimates.

In the year 1926 the total installed capacity for power generation in the Tennessee River Basin was approximately 660,000 kw., of which amount 360,000 kw. was in hydroelectric and 300,000 kw. in steam plants. The total demand for electric power was 1,100,000,000 kw-hr. When the entire system of possible navigation, waterpower, and flood-control projects is developed, it will be possible, if the market demands it, to develop, according to the report, an output of approximately 25,640,000,000 kw-hr., of which 22,600,000,000 kw-hr. would be hydroelectric power and 2,940,000,000 kw-hr. steam power. At 50 per cent load factor, Major Watkins figures there would be required a hydro installation of 4,777,800 kw. and a steam installation of 1,077,000 kw. This would mean a total installed capacity of almost eight million horsepower; and to make this primary power the steam installation would be less than 19 per cent, and the generation by steam would be less than 12 per cent of the whole amount.

Over 40 per cent of the projects would create storage. Of these the much-advertised Cove Creek Project, with a useful storage of 2,246,000 acre-feet, is the largest. The storage studies indicate that approximately 5,000,000 day-second-feet per year would be afforded by storage. This stored water would be credited with the generation of nearly eight billion kilowatt-hours per year. The conversion of secondary power into primary within the Tennessee Basin can be accomplished much more cheaply by storage than by auxiliary steam power.

The prime power output as tabulated in the report presupposes that the entire system is to be interconnected and operated as a unit, and that the market for power could absorb all the power which theoretically could be produced. Interchange of power would permit reservoirs to fill at an increased rate during periods of high flow while the greater part of the load is being carried by the run-of-river plants not regulated by storage reservoirs. This would result in a high utilization factor of the water itself; but it is a question whether an attempt to utilize all the stream flow would not lead to over-installation.

As an illustration of the possibilities to be realized by interconnection and exchange of power, Fig. 1 (Chart 61 of Appendix B, Part 1 of report) is here shown. This chart gives the composite year-mass curves for Dam No. 2, known as the Wilson Dam. The line furthest to the right represents the natural flow at this site, based on the flow records for the years 1903 to 1909, inclusive. The line to the left on the diagram, entitled "Power Regulation by Entire System," shows, by its approximation to a straight line, how nearly this ideal of complete water conservation would be approached. By way of contrast with the Wilson Dam operation, Fig. 2 (Chart 50, Appendix B, Part 1) shows the proposed operation of the Clinch River system, which includes the three large reservoirs—that at Cove Creek and those at War Ridge and Cumberland Gap, the combined useful storage of which is in excess of 3,000,000 acre-feet.

The curve for "Flow Modified by the Clinch River System" indicates the plan of drawing most heavily on this system during the driest months of the year.

Figs. 3 and 4 (Charts 44 and 29, Appendix B, Part 1) show

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Presented at the Knoxville Meeting of The American Society of Mechanical Engineers, Knoxville, Tenn., March 21 to 23, 1929.

respectively the flow-duration curves for the Wilson Dam and for the entire system.

The first seven tables of Appendix A, Part 1, of the report give the list of projects on the main stream and each tributary, and present engineering data on each project, including suggested installations, storage, and assumed costs. The number of projects on each stream, the total fall utilized, and the horsepower of installed capacity on each stream, as presented in the report, are summarized here in Table 1.

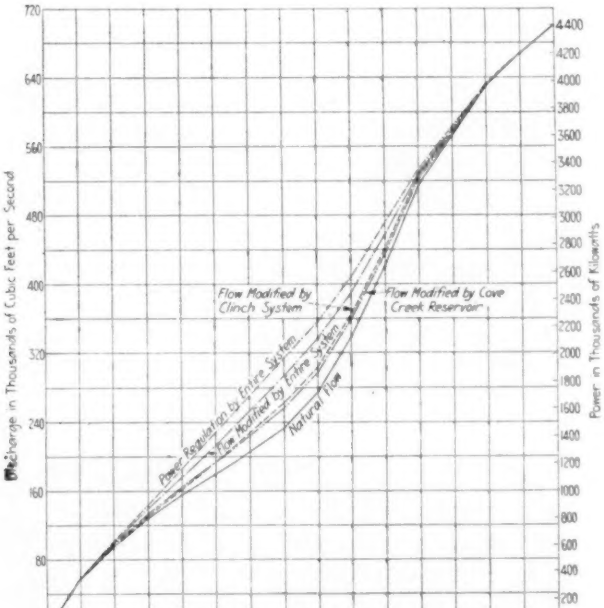


Fig. 1 Composite Year-Mass Curves for the Wilson Dam, Showing Possibilities to Be Realized by Interconnection and Exchange of Power

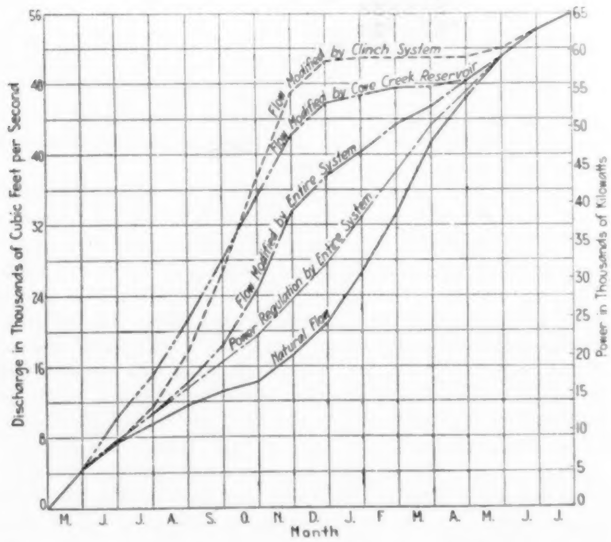


Fig. 2 Proposed Operation of the Clinch River System

Fig. 5 (Chart 1 of Appendix A) is a map of the entire area covered by the survey, and on it are indicated all the power sites included in the study. Other charts in appendixes to the report give the profiles of all the projects, the proposed transmission system to serve the completed project, and the present transmission system of the entire southeast territory, the power sites being also indicated on the last. A spot map is also given

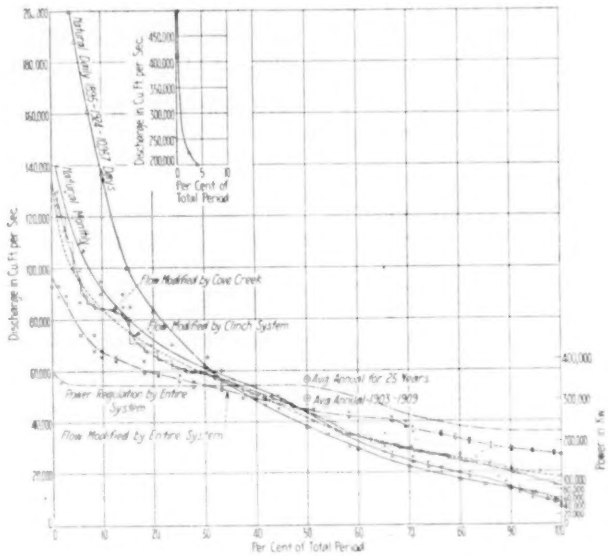


Fig. 3 Flow-Duration Curves for the Wilson Dam

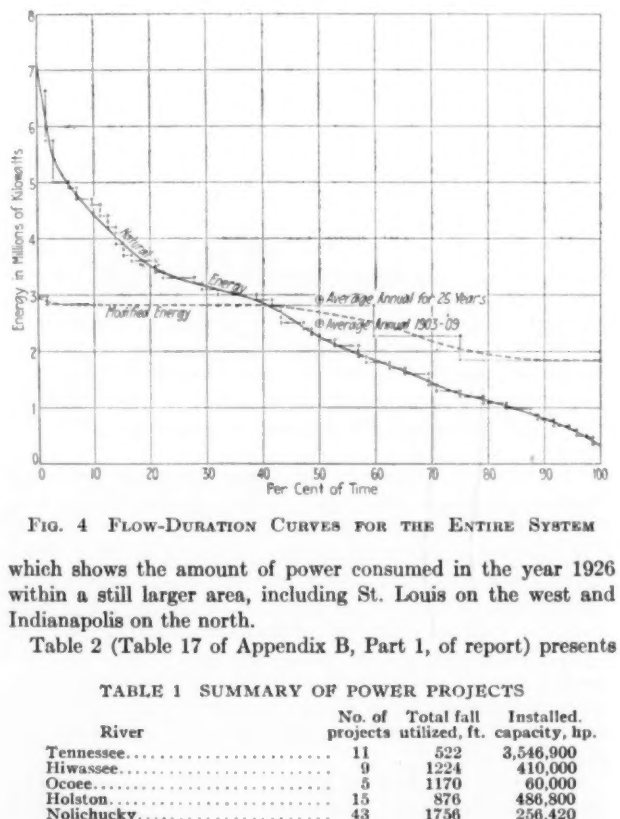


Fig. 4 Flow-Duration Curves for the Entire System

which shows the amount of power consumed in the year 1926 within a still larger area, including St. Louis on the west and Indianapolis on the north.

Table 2 (Table 17 of Appendix B, Part 1, of report) presents

TABLE 1 SUMMARY OF POWER PROJECTS

River	No. of projects	Total fall utilized, ft.	Installed capacity, hp.
Tennessee	11	522	3,546,900
Hiwassee	9	1224	410,000
Ocoee	5	1170	60,000
Holston	15	876	486,800
Nolichucky	43	1756	256,420
French Broad	11	1283	584,100
Big Pigeon	10	1500	233,500
Little Tennessee	5	1181	331,000
Duck	6	328	174,400
Elk	5	349	90,820
Clinch and Powell	7	936	443,710
Emory and Obed	7	758	95,400
Little River	2	596	32,000
Other streams	5	..	.....

TABLE 2 ECONOMIC STUDY SHOWING COST AND SELLING PRICE OF OUTPUT FOR A HYPOTHETICAL POWER SYSTEM LOCATED IN THE TENNESSEE RIVER BASIN. COST OF OUTPUT IN CONSIDERATION OF POWER DEVELOPMENT ONLY

(Power System Comprised of Plants Listed)

		Installations				Useful Storage			Output		Storage Regulation and Interchange				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Projects	Location, miles above Paducah	Hydro-steam base, kw.	Total installation at 50 per cent load factor, kw.	Steam installation, kw.	Hydro-installation, kw.	Accumulated head, ft.	Water, day-sec-ft.	Power Q. kw-days[1]	Prime hydro- (under hydro-steam prime), kw-yr.	Steam at 31.31 per cent U.F.,[2] kw-yr.	Total kw-yr.	Storage furnished to system, Q. kw-yr.[3]	Hydro natural to base, kw-yr.	Storage to regulate project at 63 per cent U.F., Q. kw-yr.[3]	Share of total storage to be borne by plant, Q. kw-yr.[3]
System	...	2,927,800	5,855,600	1,077,800	4,777,800	...	4,610,812	313,630,900	2,590,370	337,510	2,927,880	859,260	2,049,460	540,910	859,260
War Ridge	722	22,300	44,600	9,070	35,530	846.5	244,579	8,243,350	19,700	2,840	22,540	22,585	15,610	4,090	6,500
Cumberland Gap	716	11,300	22,600	3,990	18,610	842.5	166,631	5,521,450	10,000	1,250	11,250	15,127	7,910	2,090	3,320
Cove Creek	648	60,100	120,200	18,200	102,000	694.5	1,132,316	34,599,849	53,670	5,700	59,370	94,794	42,070	11,600	18,430
Clinton	635	5,200	10,400	1,600	8,800	...	.....	4,526,687	4,600	500	5,100	12,402	3,640	960	1,520
Melton	592	22,300	44,600	7,660	36,940	...	.....	17,308,912	19,800	2,400	22,200	48,422	15,610	4,190	6,660
Kingston	569	10,600	21,200	3,830	17,370	...	.....	6,390,872	9,500	1,200	10,700	17,509	7,420	2,080	3,300
Mile 0.3	652	22,200	44,400	7,830	36,570	...	.....	....	19,560	2,450	22,010	.....	15,540	4,020	6,380
Coulter Shoals	608	59,000	118,000	20,410	97,590	...	.....	....	52,170	6,390	58,560	.....	41,300	10,870	17,270
Marble Bluff	577	51,000	102,000	19,990	82,010	...	.....	....	45,280	6,260	51,540	.....	35,700	9,580	15,220
White Creek	543	77,300	154,600	27,300	127,300	...	.....	....	68,890	8,550	77,440	.....	54,110	14,780	23,480
Chickamauga	472	124,600	249,200	41,260	207,940	...	.....	....	110,100	12,920	123,020	.....	87,220	22,880	36,340
Hales Bar	431	94,400	188,800	33,680	155,120	...	.....	....	83,600	10,550	94,150	.....	66,080	17,520	27,830
Guntersville	359	100,000	200,000	35,250	164,750	...	.....	....	88,400	11,040	99,440	.....	70,000	18,400	29,230
Dam No. 3	275	179,600	359,200	75,200	284,000	...	.....	....	158,900	23,540	182,440	.....	125,720	33,180	52,710
Dam No. 2	259	336,000	672,000	141,750	530 250	...	.....	....	297 500	44,400	341,900	.....	235,200	62,300	98,970
Pickwick	206	200,200	400,400	88,250	312,150	...	.....	....	176,600	27,630	204,230	.....	140,140	36,460	57,920
Aurora	42	207,700	415,400	97,050	318,350	...	.....	....	183,600	30,390	213,999	.....	145,390	38,210	60,700
Tributaries	...	1,344,000	2,688,000	445,480	2,242,520	...	3,067,286	237,039,900	1,188,500	139,500	1,328,000	649,430	940,800	247,700	393,480

	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)
											Cost of storage		Cost of output	
Projects	Cost of hydroelectric installation, dollars	Fixed charges, dollars	Operation at $2 per kw-yr., dollars	Cost of steam, dollars	Fixed charges, 14.5 per cent of cost, dollars	Cost of steam production at $30 per kw-yr., dollars	Cost of share of storage at $28.02 per Q. kw-yr.[3]	Total debits, dollars	Value of output at storage projects at $43.43 per kw-yr., dollars	Balance credited for storage, dollars	Dollars per Q. kw-yr.[3]	Dollars per acre-foot	Dollars per kw-yr.	Mills per kw-hr.
System	870,720,071	96,213,528	5,180,740	107,780,000	15,628,100	10,125,300	.....	127,147,668	.....	......	...	..	43.43	4.96
War Ridge	17,633,489	1,967,543	39,400	907,000	131,515	85,200	182,130	2,405,788	978,912	1,244,746	55.11	2.54	43.43	4.96
Cumberland Gap	12,163,699	1,376,074	20,000	399,000	57,855	37,500	93,026	1,584,455	488,588	1,002,841	66.29	3.01	43.43	4.96
Cove Creek	34,643,243	3,756,365	107,340	1,820,000	263,900	171,000	516,409	4,815,034	2,578,439	1,720,186	18.15	0.76	43.43	4.96
Clinton	5,328,079	582,415	9,200	160,000	23,200	15,000	42,590	672,405	221,493	408,232	32.92	..	43.43	4.96
Melton Hill	10,736,366	1,192,984	39,600	766,000	111,070	72,000	186,613	1,602,267	964,146	451,508	9.33	..	43.43	4.96
Kingston	6,441,802	728,727	19,000	383,000	55,535	36,000	92,446	981,728	464,701	424,561	24.25	..	43.43	4.96
Mile 0.3	7,981,000	909,834	39,120	783,000	113,535	73,500	178,768	1,314,757	.....	......	...	..	59.73	6.82
Coulter Shoals	11,362,869	1,288,549	104,340	2,041,000	295,945	191,700	483,905	2,364,439	.....	......	...	..	40.38	4.61
Marble Bluff	12,253,084	1,405,429	90,560	1,999,000	289,855	187,800	426,464	2,400,108	.....	......	...	..	46.57	5.32
White Creek	16,968,372	1,934,394	137,780	2,730,000	395,850	256,500	657,910	3,382,434	.....	......	...	..	43.68	4.99
Chickamauga	25,105,788	2,884,655	220,200	4,126,000	598,270	387,600	1,018,247	5,108,972	.....	......	...	..	41.53	4.74
Hales Bar	15,530,411	2,105,766	167,200	3,368,000	488,360	316,500	779,797	3,857,623	.....	......	...	..	40.97	4.68
Guntersville	23,516,578	2,704,406	176,800	3,525,000	511,125	331,200	819,025	4,542,556	.....	......	...	..	45.68	5.22
Dam No. 3	40,650,067	4,715,408	317,800	7,520,000	1,090,400	706,200	1,476,934	8,306,742	.....	......	...	..	45.53	5.20
Dam No. 2	62,822,830	7,281,448	595,000	14,175,000	2,055,375	1,332,000	2,773,139	14,042,962	.....	......	...	..	41.07	4.69
Pickwick	37,915,919	4,417,205	353,200	8,825,000	1,279,625	828,900	1,622,918	8,501,548	.....	......	...	..	41.63	4.75
Aurora	48,902,475	5,618,894	367,200	9,705,000	1,407,225	911,700	1,700,814	10,005.833	.....	......	...	..	46.76	5.34
Tributaries	471,764,000	51,337,432	2,377,000	44,548,000	6.459,460	4,185,000	11,025,310	75,384,202	57,675,040	3,815,372	5.87	0.62	43.43	4.96

[1] Q. kw-days = potential kilowatt-days. [2] U. F. = utilization factor. [3] Q. kw-yr. = potential kilowatt-years.

in detail the economic results of the scheme of power and navigation development. In this table each project on the Tennessee, the Clinch, and the Powell Rivers is tabulated; but all the rest of the projects are combined in the item "Tributaries." In arriving at installation costs and costs of power output, the unit costs adopted in the report are quite noticeably higher than those actually realized by the large power companies in this section.

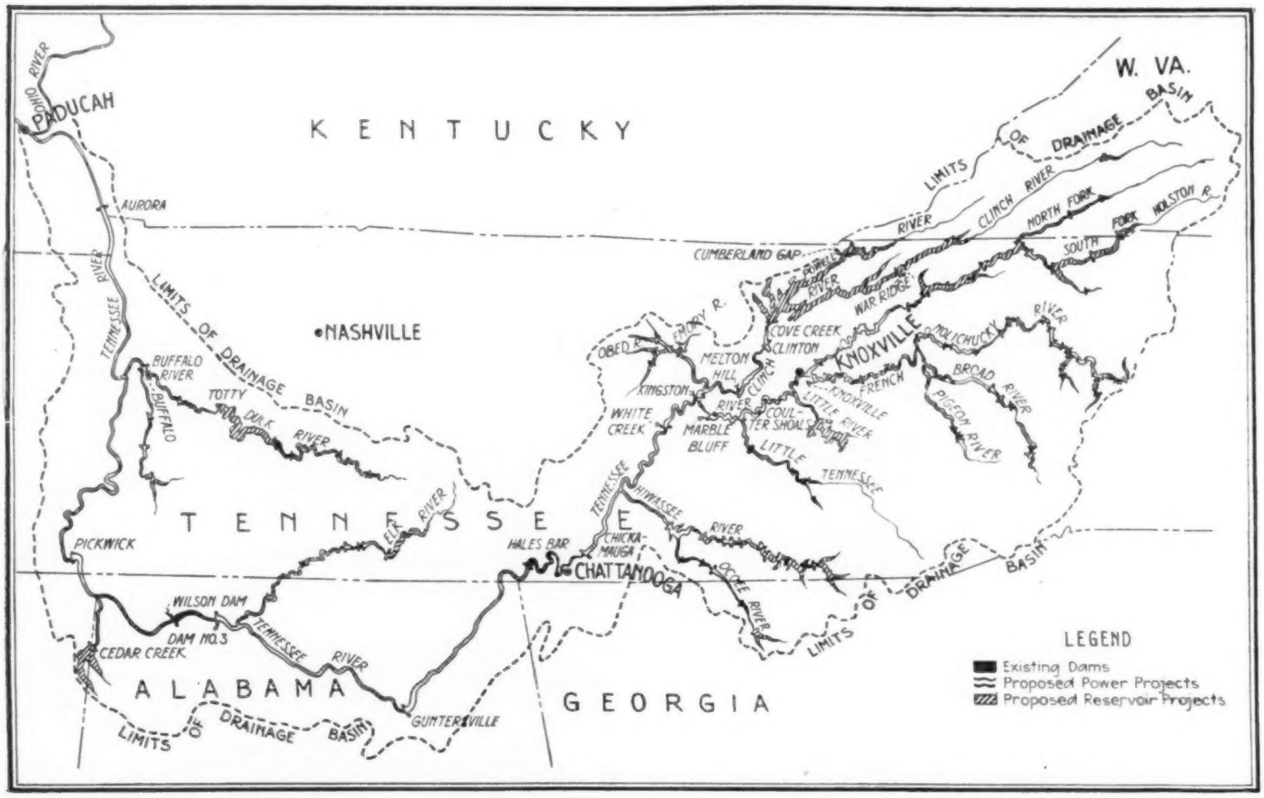


FIG. 5 TENNESSEE RIVER SURVEY. LOCATION OF EXISTING AND PROPOSED HYDROELECTRIC POWER AND RESERVOIR PROJECTS

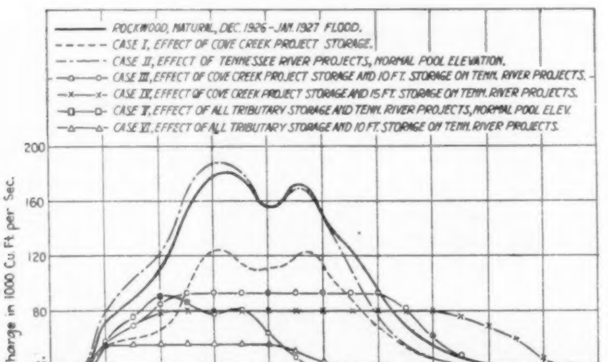


FIG. 6 HYDROGRAPHS SHOWING NATURAL FLOW AND EFFECTS OF PROPOSED PROJECTS

Appendix B, Part 2, of the report deals with the subject of flood regulation. In this connection an extremely interesting point is brought out. In its natural condition the rivers afford by their flood planes a very considerable flood-flow storage capacity, the absence of which would not only advance the crest of flood waves in point of time, but also intensify their heights. The building of a series of dams like a flight of steps, as must be done for power conservation, destroys this flood-plane storage. If each project were so operated by the use of crest gates as to maintain its pool level under normal flow at the same contour as flood flows establish (with crest gates raised), there would be no flood-plane storage; and the net effect of such construction and operation would be to intensify flood damage. If long-time prediction of coming floods were possible, then the storage reservoirs could be so manipulated as to hold back a considerable quantity of flood discharge; but there is always the possible contingency of a flood occurring when all storage reservoirs are already full. This contingency can be provided against by designing for surcharge at each dam. The studies lead to the conclusion that a surcharge of 10 ft. at each dam (or at least at each of the more important projects) will afford flood storage equal to the natural flood-plane storage of the undeveloped rivers. Accordingly spillways would be so designed that flood flows would back water to a height of 10 ft. above the spillway crest, while in normal operation of the plant the pool level would be held close to the crest level, or, on occasion, drawn below the crest level to meet load-factor requirements. (At storage-dam projects the pool would of course be drawn far below the crest level.) Fig. 6 illustrates the effect of this surcharge on flood hydrographs, and is a reproduction of Chart 8 of Appendix B, Part 2 of the report. This chart shows several hydrographs of the flood of December, 1926, and January, 1927. The heavy line represents the natural hydrograph as the flood actually occurred. Case 2 shows what would be the effect of the Tennessee River projects if normal pool elevations were held at flood-crest levels. The chart applies to the Tennessee River near Rockwood. Case 2 operation would

have increased the maximum flood flow from 180,000 sec-ft. to 190,000. Case 6 shows what would have been the effect of storage on all the tributaries together with surcharge of 10 ft. at all run-of-river plants; and if operation could be had according to this curve, the flood crest would have been reduced to 55,000 sec-ft. In other words, the flood would have been quite completely tamed. This study has been applied to all sections of the

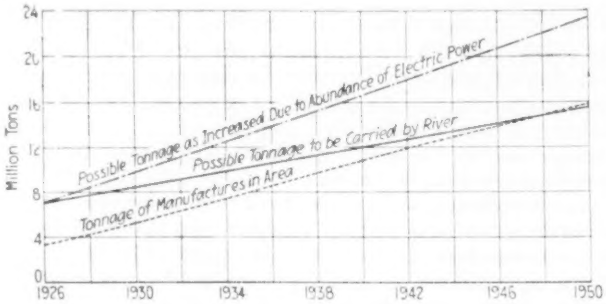


FIG. 7 GRAPH OF PROSPECTIVE RIVER FREIGHT TRAFFIC
(Area considered is that shown in Fig. 5.)

river, and as would be anticipated, the lower reaches of the river are benefited the most by this use of surcharge. This method of lessening flood heights would have a triple beneficent effect; it would lessen flood damage; it would enhance power development at times of high water by holding the head-water level a more nearly constant distance above the tail-water level; and it would greatly benefit navigation.

Appendix C of the report deals with navigation. Although in the past the Government has spent considerable sums of money in the improvement of navigation on the Tennessee River and some of its tributaries, there has never resulted what could be

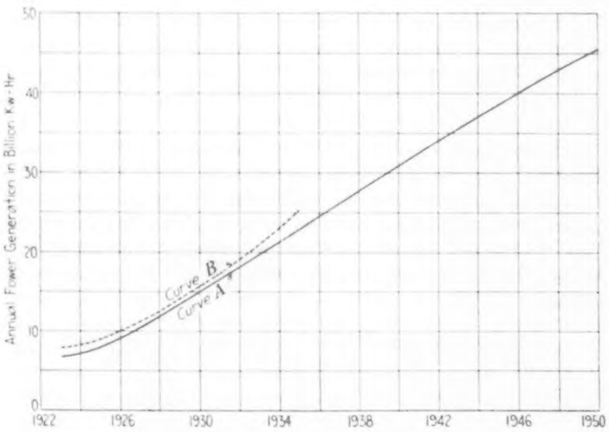


FIG. 8 PAST ANNUAL GENERATION AND PROJECTED ANNUAL DEMAND FOR ELECTRIC POWER IN AREA WHICH CAN BE SERVED BY PLANTS ON THE TENNESSEE RIVER
(Curve A: Generation in years 1923–1926 is that of ten states in area possible to be served—projected ahead to 1935 at same rate. Curve B: Plotted from data given by Prof. Thorndyke Saville in the *Manufacturers Record*, April 28, 1927.)

dignified by the name navigation. In spite of dikes, training walls, dredging, and what not, the ruling depths have been and are so shallow as to prohibit real water transportation. The plan of development unfolded in the report contemplates a completely canalized main river, with a minimum year-round depth of 9 ft., to apply from Knoxville, at the head of the river, to its confluence with the Ohio River; and in addition, really navigable depths on the lower reaches of the principal tributaries. In spite of the almost universal belief that water transportation is a thing of the past, an open-minded study of the navigation possibilities of the Tennessee River leads to the conclusion that this belief may need revision. Appendix G of the report consists of a commercial survey of the area. This includes a study of this subject of water transportation, past and possible future. Fig. 7 herewith (Chart 12 of Appendix G) is a graph of prospective river freight traffic; and if the prediction here made is borne out, the volume of freight moved by water will reach by the year 1950 the respectable figure of 24 million tons. Figs. 8 and 9 (Charts

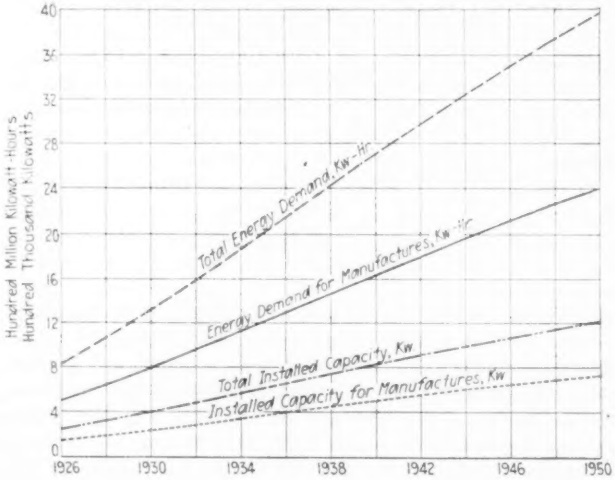


FIG. 9 COMMERCIAL SURVEY SHOWING PROSPECTIVE POWER DEMAND IN AREA
(Area considered is that shown in Fig. 5.)

19 and 20 of Appendix G) show the assumed prospective demand for power, both within the restricted area of the survey itself and in the larger territory within transmission distance. The commercial survey includes reports on the iron-ore reserves, the coal and other mineral resources, the present production of important products other than mineral; analyses of freight rates and of rail freight tonnages to, from, and across the area; and other important information.

In conclusion it can be said that while one may differ from the report in his judgment as to the suitable economic installed capacities of the many power projects covered, or as to the unit construction costs proper to be used, or as to other details, all engineers who study the report will agree that it constitutes an important contribution to the literature of water-power development, flood control, and navigation. It opens a pleasing vista of a vast and progressive industrial growth which is bound to come to the valley of the Tennessee River.

A TREMENDOUS hydroelectric development, large enough to produce about one-third of Germany's total consumption of electric energy, is being planned by the German electrical trust, "A.E.G." In the Hohe Tauern, high in the Austrian Alps, it is proposed to construct a system of underground canals to collect the waters of the various streams. These canals would begin at an elevation of from 9000 to 10,000 ft. and would have a total drop of about 5000 ft. The drop will be made in three stages with separate installations at each section. With high-tension transmission at 220,000 volts, it will be possible to send the energy profitably to central, and even to northern, Germany.

The cost of transmission is estimated at only 0.3 pfennig per kilowatt-hour, against 0.4 to 0.6 pfennig on existing systems. The result would compare favorably with the best American practice. *Power*, July 16, 1929, p. 113.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

New Wright Aeronautical Engines

SINCE 1928 the plant of the Wright Aeronautical Corporation (now merged with the Curtiss Aeroplane Company) has increased enormously, the number of employees having gone up from 1100 to 2600, showing incidentally the growth of the industry.

In the same period the Wright company designed a new line of Whirlwind engines in 5-, 7-, and 9-cylinder sizes, developing 165, 225, and 300 hp. These new power plants are lighter than the earlier ones and contain several refinements and improvements in design.

Of paramount importance is the fact that in these three new models there is a very complete interchangeability of parts, wherever possible. Furthermore, their manufacture, as now being carried on in the new Wright plant, is a good example of the application of mass-production methods to very close limits as used in the airplane-engine field. The new engines are now going into quantity production and about 25 a day are coming through. The ratio of production of the three types at present is 400 of the nine-cylinder, 300-hp. (model R-975), 50 of the seven-cylinder, 225-hp. (model R-760), and 50 of the five-cylinder, 165-hp. units (model R-540).

In addition to this, the engineers have developed in the experimental department an inverted V-type, 500-hp., air-cooled engine which promises much. According to Charles L. Lawrance, president of the company, this engine has successfully passed its 50-hr. official test, and an experimental contract for 14 of these engines has been placed by the United States Government. Mr. Lawrance says further that this type of engine will, it is believed, in a measure supersede the large radial air-cooled engines for heavy transport service, due to its greatly reduced head resistance for equivalent horsepower. While this engine has not been flight-tested, and no adequate performance data are yet available, it is said that the representatives of the Government have confidence in it as a type of engine for observation and bombing planes.

Arrangements have also been made with the deHaviland Aircraft Co., London, England, for the manufacturing and selling rights in the United States of the 90- to 100-hp. four-cylinder air-cooled Gypsy engine. It is expected that this engine will go into production during the summer. The Wright line of aeronautical engines will then comprise five models ranging from 100 to 525 hp.

The new engines embody the same principle of master-rod control which is familiar from previous Wright types.

The original article gives power curves showing also fuel consumption varying with the engine speed. (Fay Leone Faurote in *The Iron Age*, vol. 124, no. 3, July 18, 1929, pp. 148–152, illustrated, *d*)

BOILERS

High-Pressure Water-Tube Locomotive Boiler

IN THE February, 1928, issue of *Railway Mechanical Engineer*, the author proposed the use of an all water-tube high-pressure boiler with inclined straight tubes in the barrel. The proposed design, however, did not adequately take care of the cleaning difficulty, and in order to overcome this, another principle has been evolved which he calls the principle of progressive circulation in which every drop of water must pass successively up and down through each of a series of cross-drum tube sections before it finally arrives at the firebox zone.

An economizer, or high-temperature feedwater-heating section, is placed next to the smokebox. Feedwater is normally furnished to the economizer at 200 deg. fahr. by a pump, such as the Worthington, and is heated in successive passes 350 deg. higher before it is pumped into the high-pressure or evaporative system. The economizer consists of four inclined cross-box tube units, and the water flowing into the bottom cross-box of the first unit flows up the incline tubes to the upper cross-box, and thence down the side tubes (out of the gas path) to the bottom of the second unit, up the second unit, and so on. The water becomes progressively hotter with each pass. From the top of the last economizer unit the water is led to the boiler feedwater pumps for admission to the evaporative system.

Five cross-drum tube units, located next to the economizer, together with the firebox form the evaporative system. The hot water from the economizer is pumped into the lower drum, down a side tube to the lower drum of the second unit, up the second unit, and so on. Steam formed in these cross-drum units passes out by a common escape pipe at the top, but the water itself must flow progressively up and down each unit until it arrives in the firebox zone in the rear. This direction of flow is not only due to the inflowing feedwater, but to the use of smaller tubes for upflow than for downflow. The former in the active heat zone naturally set up a rising circulation.

In this connection it is well to call attention to the changing properties of steam with increasing pressures, which create changing conditions in the design. While the total heat required per pound of steam changes little, more heat is required to get the water to the boiling point for higher pressures, but when once reached, less heat is required for evaporation. This is shown as follows:

Boiler pressure, lb. per sq. in.	Heat in boiling water, B.t.u.	Heat of vaporization B.t.u.
800	506	687
200	361	838

The result is that the feedwater-heating function of the boiler becomes more important with rising pressures and the evaporative function relatively less so.

After heating the feedwater from 200 deg. to 350 deg. fahr. in the economizer, the hot feedwater entering the cross-drum units of the evaporative system must first be heated to 520 deg. (the temperature of saturated steam at 800 lb. pressure) before steam will form, so that probably the first two or three cross-drum units will be needed to perform this function, leaving the active evaporation to the two or three rear cross-drum units, the combustion chamber, and the firebox, which are located in the hot zone of the boiler.

This emphasizes the importance of the work of heating the feedwater as an essential element in the design of a high-pressure boiler. The original article describes the details of design but

states that these are not to be taken as a finished design. (Louis A. Rehfuss in *Railway Mechanical Engineer*, vol. 103, no. 5, May, 1929, pp. 240–242, 3 figs., *d*)

ENGINEERING MATERIALS (See SPECIAL PROCESSES: Pre-Mixed Concrete in Cincinnati)

FUELS AND FIRING (See SPECIAL PROCESSES: Thylox Process for Removing Hydrogen Sulphide from Gas: POWER-PLANT ENGINEERING: Fineness of Pulverized Coal)

Catalysis in Hydrogenation Processes

THE present authors have carried out a series of experiments on the action on catalysts on mixtures of hydrogen and carbon monoxide. Their method of producing carbon monoxide was to dehydrate formic acid by concentrated sulphuric acid but they devised an apparatus permitting continuous production of carbon monoxide.

As a catalyzer they used a mixture prepared in the following manner. The following quantities were dissolved in distilled water: 200 gr. of nitrate of cobalt, 90 gr. of nitrate of copper, and 10 gr. of nitrate of manganese. This mixture was evaporated at 105 deg. cent., whereupon the temperature was gradually raised to 150 deg. cent. (302 deg. fahr.) in order to oxidize partly the nitrates, the end of the operation being indicated by the disappearance of brown vapors. It is claimed that this mixture of nitrates and oxides produced better results than the usual materials. It has been found that the gaseous mixture must be carefully purified before being admitted to the catalyzer. Activated carbon was found to be the best method of purification. The results of the tests are given in the original article in the form of curves and tables. (Benito A. Buylla and J. M. Pertierra in *Ingenieria y Construccion*, vol. 7, no. 77, May, 1929, pp. 225–231, 4 figs., *e*)

New Method for Burning Soft Coal as Generator Fuel

THE essential element of this method is the use of a special nozzle made of steel and water jacketed. This nozzle consists of an 8-in. pipe inside of a 14-in. pipe, leaving a 3-in. space between them for a water jacket. The small pipes for the steam and air to pass through from the inner chamber to the fire are $1^1/_2$ in. in diameter and are welded solidly into place. The top is made conical with a heavy eyebolt welded into it for raising and lowering the entire nozzle up or down through the charging door. The bottom head is also welded on with two pipe connections for the water inlet and outlet. The outlet pipe extends to the top or conical part of the nozzle so as to insure proper circulation. The installation of the nozzle is very simple as it is placed right on top of the grate bars and the inlet and outlet water pipes hold it in place. The pipes, of course, must be brought through the side walls of the generator underneath the grate bars.

After making and installing the first steel nozzle, as described above, on an 8 ft. 6 in. set, the company operated the generator with it for four weeks and could hardly see any ill effects on the nozzle from the heat or from charging.

The company kept accurate records of the saving made with different mixtures of coal and coke and these are tabulated below.

	100% Coal	75% Coal 25% Coke	40% Coal 60% Coke	100% Coke
Make per hr.				
Without nozzle	60,000	70,200	76,900	85,000
With nozzle	67,000	75,000	85,000	
Fuel per M				
Without nozzle	31.0	29.1	27.8	26.5
With nozzle	27.0	25.5	25.5	

These results were obtained while using a grade of soft coal which was very soft and friable in structure, readily broken up, and containing a large percentage of fines.

One of the main features of the water-cooled air and steam nozzle not to be overlooked is the fact that the waste water from the tar well can be used for cooling water and a considerable amount can be disposed of in this way by evaporating it to the atmosphere. In most gas plants the disposal of waste water is a serious problem and the water-cooled nozzle will help partly, if not entirely, to overcome it. If pure water is used it can be discharged into the boiler feedwater heater, or in plants where exhaust steam is used for gas making it can be made into steam and discharged into the accumulator. The amount of water required depends, of course, on the outlet temperature of the water and this can be governed by a suitable valve on the supply line. In an 8 ft. 6 in. generator when converting it into steam, 2 gal. per min. is necessary. (James N. Paff, Peoples Gas Company, Glassboro, N. J., in *Gas Age Record*, vol. 73, no. 18, May 4, 1929, pp. 605–606, *d*)

Alcohol Motor Fuels

THE present ratio of alcohol production to gasoline production is 1 to 125, very little of the alcohol being used for motor fuels.

The investigation of the United States anticipated by two years the official commissions in Europe in reaching the conclusion that motor alcohol, to be feasible at all, must be put out in some form readily blendable with gasoline. It is well known that ordinary 95 per cent alcohol is not miscible with gasoline without the use of expensive homogenizers, but that anhydrous alcohol (99 per cent to 100 per cent) will mix with gasoline in all proportions. The problem of producing large quantities of anhydrous alcohol must, therefore, from any sound economic standpoint, be solved as a preliminary to the production of alcohol-gasoline blends. The necessity of making anhydrous alcohol in commercial quantities having been clearly established, the research program was launched and finally resulted in a continuous process of distillation yielding anhydrous alcohol in large volume and at a minimum cost.

Interesting confirmation of this analysis of the fuel-alcohol problem and the conclusions was forthcoming in due course from both the British and French official commissions created to study this subject when they announced, in effect, that the most feasible method of utilizing alcohol in motor fuels was in the form of a simple blend of anhydrous alcohol with gasoline, or other available hydrocarbons. In the meantime, Americans were doing that very thing, and extensive tests have long since been carried out in the actual use of such fuels in motor cars, motor boats, airplanes, block tests, etc. The merits and faults of alcohol-gasoline blends were established, and the position of such fuels fixed in the scheme of things.

The composite fuels, made simply by blending anhydrous alcohol with gasoline, have been given most comprehensive service tests extending over a period of eight years. Hundreds of thousands of miles have been covered by standard motor car, tractor, motor boat, and airplane engines with highly satisfactory results. With intelligent adjustment of compression and feed, to capitalize the advantages inherent in alcohol blends, they easily excel gasoline on every point important to the motorist. The superiority of alcohol-gasoline fuels is now safely established by actual experience.

It would appear that there are no technical difficulties remaining either in the making of an alcohol suitable for fuel blends or in the use of fuels made therefrom. The future of alcohol motor fuels is therefore largely an economic problem. If gasoline becomes more expensive there will be a greater incentive to use

alcohol, providing this can be done under the restrictions imposed on the use of industrial alcohol in this country. (M. C. Whitaker, part of symposium on Motor Fuels and Oil Conservation, Chemists' Club, New York, Sept. 30, 1925, abstracted through a reprint in *Engineers and Engineering*, vol. 46, no. 6, June, 1929, pp. 147–148, *gc*)

Pulverized-Lignite Firing

THE San Antonio Public Service Co. has been burning powdered Texas lignite during the last three years at its Comal Plant in New Braunfels, Texas. The experiences with this fuel are now reported, in part, as follows:

Lignite pulverizes easily, but contains a very large amount of moisture.

The temperature of the gas leaving the driers and the temperature of the coal leaving the driers should be above the dewpoint of the gas to avoid condensation of the vast amount of moisture.

The ash content is very high in lignite, the ash being extremely light and fusible.

The coal feeders have to be larger for a given capacity, owing to the lower B.t.u.

The bottom rows of the boiler tubes should be spaced wider than normal, so that the heavy deposits of ash on the tubes cannot bridge over.

The furnace area should be larger so that molten ash will not be carried up into the boiler and solidify on the tubes, making it necessary to carry the CO_2 in the boiler at a low figure; also to take care of large volumes of moisture and ash.

The high moisture content of the coal and the impossibility of driving out this moisture successfully ahead of the boiler makes the efficiency that can be expected in an especially designed boiler approximately 80 per cent.

The design of the boilers represents a departure from the standard practice. In the first installation the rear wall and about two-thirds of the side walls were covered with thin tubes. The remaining one-third of each side wall and the front wall were of the Detrick hollow-wall construction through which the preheated air passed on its way into the furnace through ports in the front wall.

Air under a pressure of from 10 to 15 in. of water was used to blow the coal through the burners. When the coal stream entered the furnace and began to burn it was met by air coming through the ports in the front wall.

Certain defects in the operation of these boilers were discovered, thus:

The distribution of air through the front wall was not correct. Too many air ports made the velocity of preheated air, striking the down stream of the coal, too low. This was remedied by closing entirely the air ports in the bottom three belts, and by checking off about one-half of the area of the remainder of the air ports, a brick being placed in each opening.

The spacing of the tubes in the bottom rows of the boilers was found insufficient, even with the elimination of the second and fourth rows, and it was decided that in future boilers additional spacing would be provided.

It was seen that the water-screen capacity was not sufficient to cool the molten particles of ash as they dropped into the ashpit, so it was concluded that in future boilers this water screen would be doubled. (Fig. 1 shows how it has been done.)

The most serious difficulty encountered on the original boilers was the fan capacity, both induced and forced draft. This capacity was too small to give the rating expected by the designers on the original layout. The fan capacities on the original boilers were increased. The new boiler was designed with sufficient fan capacity. The increase in fan capacity enables all three boilers to be run up to their rating, 350 per cent normal.

In addition to this it was found that most of the unusual troubles of the plant were caused by the large amount of ash, about 90 per cent of which tended to go through the boiler. This accumulation must be prevented and it was found that the mechanical soot blower becomes of increasing importance even

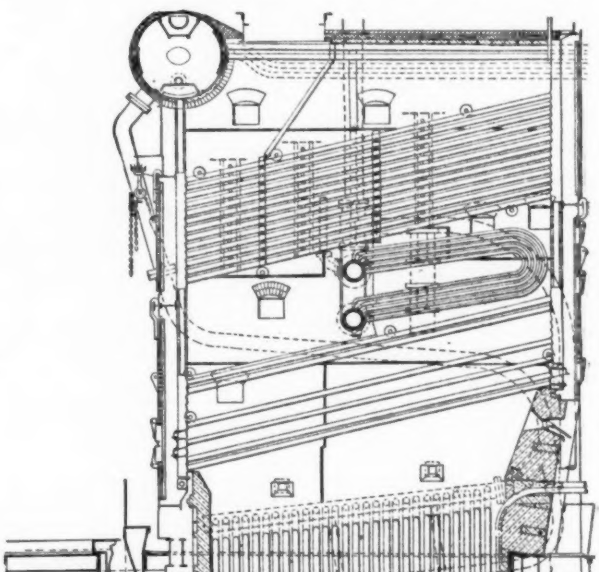


Fig. 1 Sectional Elevation of Boiler No. 3, Comal Plant, New Braunfels, Texas, Designed to Operate on Pulverized Lignite

though it has slightly changed its function from that of a remover of soot from the tubes to that of an agitator. A new function of the soot blower is to keep the ash moving through the boiler and not to allow it to accumulate. It has been found necessary to operate the blowers at more frequent intervals, such as every four hours. Fig. 1 shows how the soot-blower elements were spaced in the new blower in an effort to find the strategic points of ash accumulation. This is important as the successful stirring

of the ash to keep it moving determines the number of hours the boilers can be kept in service without loss of capacity and superheat or burning of tubes.

In addition to this feature, in the latest boiler was also incorporated a rotary type of burner recommended by the manufacturers. The following results were obtained on test:

The boiler was operated at a steam-flow rate of 245,000 lb. per hr. for a period of $7^1/_2$ hr., during which time the efficiency as calculated by the heat-balance method averaged 81.8 per cent. This steam flow is equivalent to 359 per cent of rating for the boiler, superheater, and furnace combined, or 7515 developed horsepower. This compares with the manufacturer's guarantee of 232,000 lb. of steam per hr. for a period of 4 hr. and an efficiency of 79.5 per cent. The heat-liberation rate was 18,400 B.t.u. per cu. ft. of furnace volume, compared with a guarantee of 18,050. The temperatures of the flue gas leaving the boiler and preheater, respectively, were 630 deg. fahr. and 423 deg. fahr., compared with 640 deg. fahr. and 440 deg. fahr. on guarantee. The temperature of the air leaving the preheater was 469 deg. fahr., compared with a guarantee of 447 deg. fahr.

These results should not be confused with those with boilers using higher grades of coal. An ultimate analysis of an average sample of lignite is given below, showing the high moisture and ash content.

ANALYSIS OF COAL AS FIRED AFTER LEAVING THE DRIERS

	Per cent		Per cent
Moisture	29.05	Oxygen	11.24
Carbon	43.90	Nitrogen	0.75
Hydrogen	3.12	Sulphur	1.34
		Ash	10.60

(V. H. Braunig, Supt., Electric Dept., San Antonio Public Service Co., San Antonio, Texas, in *Power*, vol. 70, no. 1, July 2, 1929, pp. 13–16, 3 figs., *d*)

FURNACES

Brass-Melting Furnace With Metal Retort

DESCRIPTION of a brass-melting furnace developed through cooperative research by the American Gas Association and the American Gas Furnace Company, Elizabeth, N. J.

The essential feature of this furnace is that the usual crucible and refractory-lined furnace have been supplanted by a retort of special alloy metal. This alloy is said to be able to withstand repeatedly working temperatures in excess of 2000 deg. fahr. in contact with molten metal; a single retort made from this alloy has already served for more than 250 heats and is none the worse for wear.

This new brass melter consists of a revolving metallic retort externally fired and enclosed in a shell heavily insulated and refractory lined. The insulated sheet-steel drum or shell is mounted on two bearings held by a steel frame so that it can be tilted at any desired angle. Ten gas burners, five on each side, are mounted on this drum in such a manner that they fire into its interior. Within the drum is the special alloy-metal retort so mounted that it revolves with a motor and variable chain and gear drive.

Air under pressure for combustion is supplied to the gas lines serving the burners and the gas-air mixture can be so regulated as to provide any desired atmosphere—oxidizing, reducing, or neutral—within the combustion chamber, which is the space between the shell and the retort. In this case a slightly reducing atmosphere is maintained so as to prevent oxidation of the retort. The fuel consumption is said to be from $2^1/_2$ to 4 cu. ft. of gas per pound of brass melted. (*Brass World and Plating Polishing-Finishing*, vol. 25, no. 5, May, 1929, p. 108, 2 figs., *d*)

HYDRAULIC ENGINEERING

"Hydrautomat" Installation in India

THE purpose of the "hydrautomat" is to convert the energy from low falls of water in canal systems and rivers into air power. This air power in the form of compressed air or vacuum can be used at some distance away, for example, for the purpose of raising water.

The system is free from any moving parts and requires superintendence only to start or stop. Moreover, it can be safely assumed that the initial cost should be relatively low inasmuch as the construction is mainly of reinforced concrete.

In the installation under review, the system may be considered in two parts: (*a*) rarefier or vacuum power unit which is situated at the fall, (*b*) lifting or pumping unit which in this case is raising water from a drain about 1500 ft. away.

The rarefier illustrated in Fig. 2 comprises a syphon which is raised to a height slightly above the vacuum required at the lifter. In this instance the syphon rarefier is built into existing masonry piers and is 8 ft. 6 in. wide, while the entrance waterway is 6 ft. deep.

In the central or partition wall *B* are fixed three priming ports *F* which, when starting up, are used to prime the syphon. When swung open by levers from the outside, these ports give a free passage of water from upstream to downstream. Taking the lowest port which is always submerged, water passes from the upstream leg, and on splashing on the downstream, traps much air from the inside of the syphon. The air passes out of the syphon and is freed to the atmosphere. This has the effect of creating a partial vacuum inside the syphon and the water level rises until the next higher port comes into action, and so on, until the syphon commences running when all priming gates are closed For quite a large syphon of this description and to a vacuum of 16 ft. with a fall of about 5 ft., the priming is accomplished in a matter of 20 min.

Flow now takes place like an ordinary syphon, upward in passage *A*, over the partition wall *B*, and thence downward in passage *C*, and so to downstream. Aspirating fins *D* which are perforated are arranged in the throat of the syphon at intervals across the width. These fins communicate with an air duct *E* built into the top of the partition wall or crest *B*, which duct communicates with the air main outside, connecting the lifting unit.

The water in passing these perforated fins draws in air from the air main which enters the water in the form of small air bubbles. This emulsion of air and water passes downward in passage *C* and out of the syphon where the air is freed to the atmosphere. Thus a partial vacuum is created in any chamber connected to the air main.

As air is admitted to the syphon in increasing volume the discharge slows down until a point is reached where the syphon becomes unstable and finally breaks down. To insure that the syphon runs steadily with the maximum air capacity and at the same time is free from any possibility of breaking down, a special governor gear is arranged which effectively and simply controls the volumes of air admitted under all conditions.

It will be understood that an air main connects the rarefier to the lifter and thus the rarefier is continuously extracting air from the lifter and maintaining a partial vacuum.

Referring now to Fig. 3, it is observed that the units consist of a concrete chamber having an inlet at the lower level *A* communicating with three lift pipes *B* and an outlet from chamber *D* to the higher level *C*. Inside each lift pipe *B* is placed an air inlet *C* communicating with the atmosphere by air pipes *F* rising through the roof of the lifter.

Assuming that air is shut off from the air inlets and that the

principal air valve on the vacuum main is opened, then the water level inside chamber D will rise as it will also inside the lift pipes B. The air pipes F are now opened to the atmosphere with the result that air enters the water through the air inlets E which are placed slightly above the lower water level. Aerated columns are thus formed inside pipes B which, having a lower specific gravity than the solid water column inside chamber D, rise and overflow into the chamber D, and so to the higher level C.

The air which was contained in the water is liberated in chamber D and is continuously extracted by the rarefier.

Flow in the lifter is continuous and wide variations in head and quantity can be given.

In this instance, pumping is from drains and the lift is variable, in fact, the plant is arranged for pumping from 0 to 10 ft., and in order that reasonably efficient conditions will prevail over most of the range, the air inlets can be raised or lowered to follow the lower water level, although it is not necessary to attend strictly to this adjustment.

The lifter is designed for 12 cu. sec. discharge.

The photographs show the outward appearance of the rarefier and the lifter and these are by no means unsightly and show on the outside little of what goes on in the interior.

This type of hydrautomat may be used in irrigation for pumping water into higher level distributaries, pumping water from drains, etc., and other work connected with water supply.

On the other hand there are systems which compress air in a similarly simple manner and the air power is conveyed to batteries of tube wells where pumping is carried out by air-lift pumps. (*Indian Engineering*, vol. 85, no. 11, March 16, 1929, pp. 150 and 2 pages of illustrations, *dA*)

INTERNAL-COMBUSTION ENGINEERING (See AERONAUTICS: New Wright Aeronautical Engines)

MOTOR-CAR ENGINEERING

Auburn Front-Wheel-Drive Automobile

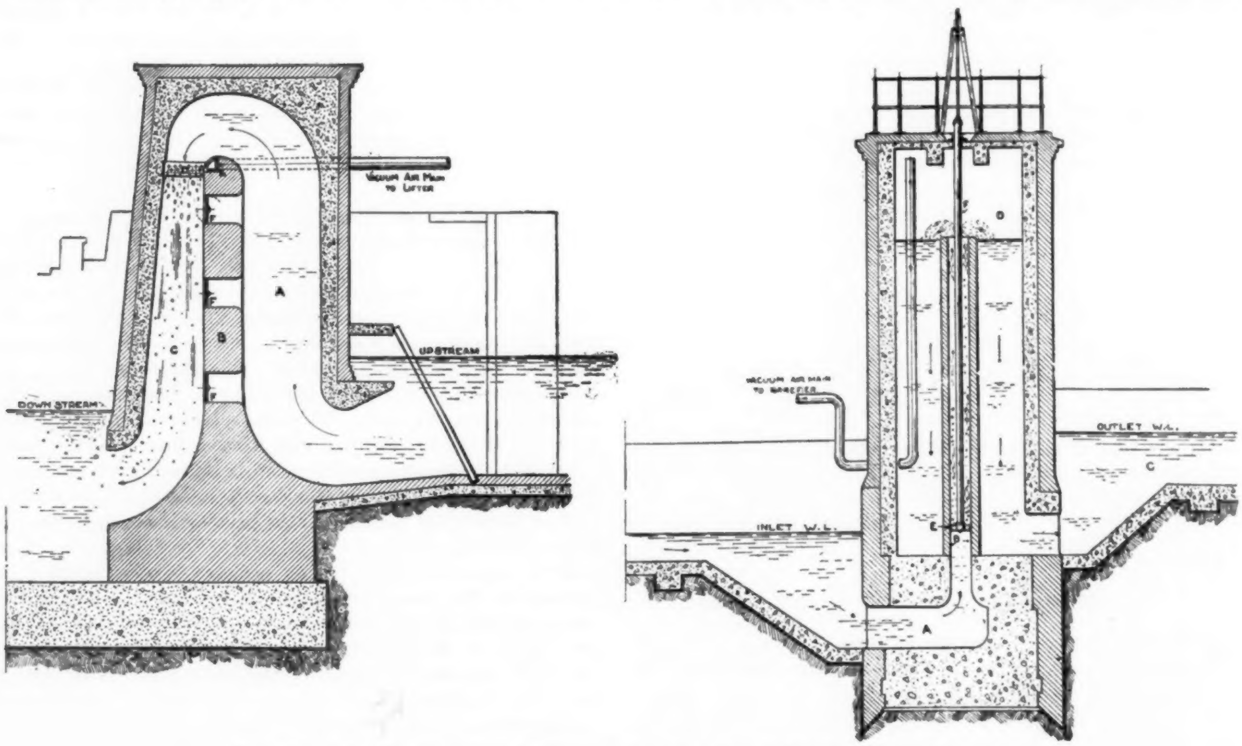
THE CORD front-drive passenger car is today the only commercially produced American car of its type.

As it is a front-wheel-drive car, all power transmission units are located ahead of the dash, with the general order reversed. Thus the engine is of nearly normal eight-cylinder design turned around, with the flywheel housing at the front. The next unit forward is the clutch, then the transmission, and the differential, all of these being bolted together in a unit power plant.

From the differential, power is transmitted to the wheels by means of universally jointed driveshafts, the wheels themselves being pivoted to a tubular dead axle which is bowed forward in an arc to clear the driveshafts and differential housing. Both drive and torque reaction are taken through the front springs, these being of the double $^1/_4$ elliptic type, with one spring above, and one mounted below, the frame side channel.

The entire design obviously reduces the unsprung weight, which is reflected in better riding qualities. Moreover, the car weight with gas tank full is exceptionally well balanced, there being only about 10 to 20 more pounds on the front than on the rear wheels. Further, the sturdy frame construction, made possible by the elimination of the rear axle kick-up and the unconventional bracing, enables the use of lighter bodies, the total weight of the four-door sedan, with its $137^1/_2$-in. wheelbase, being only about 3975 lb.

The driveshafts have an unusual universal-joint construction, consisting basically of two universal joints at 180 deg. to each other. A single universal joint, of course, does not have uniform angular motion with angular deflection of the shafts, but a harmonic motion. The two directly opposed universals balance out the two harmonic motions, giving constant velocity to the wheel spindles. In order to maintain the amplitude of the harmonic motion identical for the two joints, they are attached to a



FIGS. 2 AND 3 HYDRAUTOMAT INSTALLATION ON THE UPPER CHENAB CANAL, PUNJAB

ring between them in such a manner that the ring at all times bisects the angle between the universals, rotating in one plane for any given wheel-spindle position. Moreover, the universals are connected by a ball joint in the center of the ring, so that the wheel-spindle and driveshaft center lines will always intersect, as otherwise erratic motion would be produced.

This design of the outer universal assembly has produced the additional advantage of an unusually small turning-circle diameter. The maximum angular deflection of the joints is given as $41^1/_2$ deg., which gives a turning-circle diameter of only 42 ft. Thus two disadvantages commonly attributed to front-drive cars have been eliminated by this design.

The steering action and brake hook-up are said to be rather unusual. The usual gearshift lever is replaced by a horizontal rod extending through the dash below the instrument board. The form is entirely unlike that used on rear-drive cars and is described in some detail in the original article. (Athel F. Denham, in *Automotive Industries*, vol. 60, no. 26, June 29, 1929, pp. 974–980, illustrated, *dA*)

POWER-PLANT ENGINEERING (See FUELS AND FIRING: Pulverized-Lignite Firing)

The Hammond Submerged-Combustion Boiler

THIS boiler has been previously referred to in MECHANICAL ENGINEERING, vol. 50, no. 1, Jan., 1928, p. 75, and is built by Submerged Combustion, Ltd., of London. It is said its thermal efficiency is of the order of 97 per cent. It consists of three main parts, a special submerged burner, an exchanger-circulator, and a recuperator. In addition there are such auxiliaries as air compressor, gas piping, etc. The boiler consists of:

1 An upper part or head where the gases and air enter in order to reach the mixture. The latter consists of a series of very fine ports dividing the fuel and causing it to burn in fine layers, which insures a perfect mixture of air and gas no matter what may be the conditions of flow and pressure.

2 The "velocity passage," the section of which is so calculated as to give the explosive mixture, even when its amount is at the minimum, a sufficient velocity to prevent the spread of flame backward.

3 A combustion chamber consisting of a tube of highly refractory material with a metal sheath. The assembly of the parts of the burner is so arranged as to permit their free expansion. The burner connects with an air compressor and a distributer, the purpose of the latter being to maintain a perfect proportion of the gas in the fuel, independently of the pressure of air and gas, the volume of flow, and the pressure required to form an explosive mixture.

The Exchanger-Circulator. The heat exchanger consists of a vertical tube *DEF*, Fig. 4, in which and in the same direction circulate the products of combustion and the water of central heating. The circulation there is very active, as a result of which there is established a state of emulsion in the water and in the current created by the exhaust gases. While the dimensions of the heat exchanger are very small, there is a sufficient heat transfer because of the extreme subdivision of the products of combustion and their direct contact with the liquid which they are supposed to heat. The exchanger has placed above it the separator *V*.

The recuperator has for its purpose the taking away of such heat as the exhaust gases may still contain, and consists of a series of partitions forcing the gases and water to circulate in directions opposite to each other, the gas bubbling through the water.

Circulation. The products of combustion rise in the vertical tube *DEF*, mixing with the cold water and giving up to it the greater part of their heat. They then pass through the annular passage, and thence through the connection *H* into the expansion vessel, from which they go to the recuperator and finally to the exhaust pipe. While it is traveling through the recuperator the gas is in direct contact with the water returning to the boiler, that is, with the coolest water in the entire circulation, and this causes as complete cooling of the gases as possible.

The water which is to be heated enters the apparatus by pipe *A*, passes through the recuperator, and then into the expansion vessel, whence it goes to the burner through the connection *BCD*. After having been emulsified it rapidly rises in the central tube of the exchanger *DEF*, going next to separator *V*, whence it is projected against the external wall. After it has attained its maximum temperature it flows by gravity into the heating circuit through pipe *G*. The water extrained by the exhaust gases into the annular passage *FE* falls at the exit from connection *H* into the expansion vessel, whence it returns to the burner.

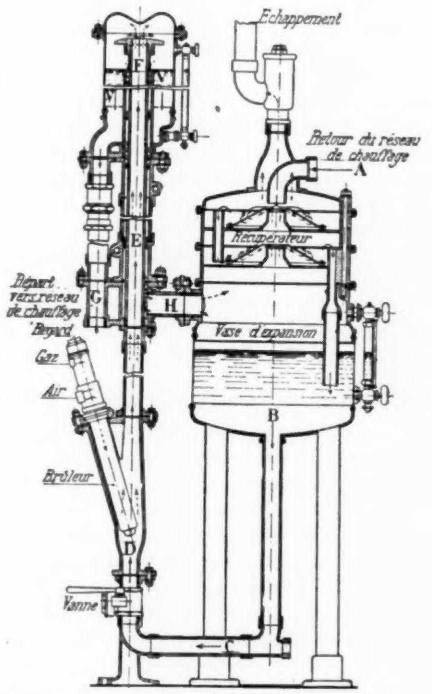


FIG. 4 VERTICAL SECTION OF THE HAMMOND GAS-HEATED SUBMERGED-COMBUSTION BOILER

(*Depart vers reseau de chauffage* = flow outward into heating-system piping, *Regard* = direction; *Gaz* = gas; *Bruleur* = burner; *Vanne* = blade; *Echappement* = exhaust; *Retour du reseau de chauffage* = return of flow from heating-system piping; *Recuperator* = recuperator; *Vase d'expansion* = expansion vessel.)

The boiler is connected directly into the heating circuit. This arrangement has the advantage that it permits making use of the low density of the emulsified column *DEF* in order to promote the circulation in the entire heating-system piping. The burner may be placed at any desired level, while the recuperator has to be located in the upper part of the installation. The lower the burner is placed the higher the emulsified column becomes, and the more assistance is available for the circulation. It does give, however, an increase in compression in order to permit the explosive mixture to reach the combustion chamber. (G. Prud'hon in *Le Genie Civil*, vol. 94, no. 22, June 1, 1929, pp. 525–527, 2 figs., *d*)

Fineness of Pulverized Coal

THIS article is based on the practice of the ball-mill installation of the Western United Gas and Electric Co. at Aurora, Ill. Because of the grinding characteristics of ball mills, the fuel burned in this plant (three 1000-hp. boilers) averages about

93 per cent through 200 mesh and 100 per cent through 50 mesh.

From many months' operating experience it has been determined that the mills use 0.33 lb. of balls per ton of coal and 333 lb. of balls are fed in for each 1000 tons as determined from the weighmeter readings. The initial charge to each mill is 14,700 lb. of Herculite steel made up of 3, 2, $1^1/_2$, and 1-in balls. After the initial charge, only 3- and 2-in. balls are used, the proportion of smaller balls being maintained automatically by wear.

Power consumption of the mills alone averages about 14.1 kw-hr. per ton of coal pulverized. Due to the characteristics of the mills operating at all times with a constant charge of balls, the power consumption over the entire load range is almost constant and the partial load at which the mills are operated is considerably above what it would be if the mills were operated at full capacity continuously. At 5000 lb. per hr. the exhauster fans driven by 20-hp. motors require about 9 kw. each. Total power consumption of the entire boiler unit including mills, fans, regulators, feeders, and induced-draft fans averages about 53 kw-hr. per ton of coal.

Total maintenance of mills, exhausters, and feeders amounts to about 1.6 cents per ton. This includes the replacement of some liners at the feed end of the mill which is the only section showing appreciable wear. Liners are of the same material as the balls, i.e., Herculite steel.

Comparative efficiencies of the various power units are given in the original article which also contains a general description of the installation.

A typical analysis of the coal used is given in the original article. (*Power Plant Engineering*, vol. 33, no. 10, May 15, 1929, pp. 582–585, 6 figs., *dc*)

Slag Tapping in Pulverized-Coal-Fired Boilers

THE first successful application of this process on a large scale was made at the Chas. R. Huntley Station of the Buffalo General Electric Co. where comparatively low fusion ash coals are burned. The boilers there are of the Babcock & Wilcox cross-drum type. The furnace under the first boiler included a well 8 ft. square and 11 ft. deep, sunk into a furnace floor that was 17 × 25 ft. and averaged 12 ft. 9 in. to the bottom row of boiler tubes. The sides of this well were formed by $3^1/_4$-in. tubes on 6-in. centers which were originally covered on the fire side with solid calorized-steel Bailey blocks. These blocks did not stand up, however, and were later replaced with refractory-faced Bailey blocks, while the sloping wall tubes above the well were covered with clay tile. This made it possible to increase the furnace temperature to the point where the ash became molten and dropped directly or ran from the clay tile into the well. Upon reaching the floor the slag formed a pool remaining in the molten state because of the high temperature of the furnace above and the absence of cooling tubes below. The fluid could be tapped through a hole in the bottom of the well, but the problem was to find a satisfactory means of disposal after tapping. Several schemes were considered, and it was finally determined to use sluicing. Experiments on dropping slag directly from the furnace into a concrete buggy filled with water were therefore made. Strangely, no explosion occurred and there was little sputtering. The slag stream formed its own insulating tube to the bottom of the buggy and built up as if there were no water on top of it. The sheet-metal casing on the bottom of the buggy became red hot long before the surface of the water showed any signs of boiling. When the bucket was half full of slag, it was rolled to one side and some fifteen minutes later it was emptied with the interior of the slag still red hot.

Sluicing was then tried out by placing an 8-ft. length of 12-in. channel iron, sloped at an angle of about 30 deg., under the spout of the original boiler and placing two $^3/_4$-in. water nozzles at the top, so as to sweep the channel clean. The lower end discharged into an ash car. These tests on sluicing led to observations that were of great value in arriving at the final solution. The slag stream was broken into small pieces by the mechanical force of jets, and these pieces in turn tended to shatter into smaller pieces, owing to the rapid chilling effect of the water made possible by the exposing of greater surface areas per unit volume of slag. These facts indicated the necessity of using comparatively large volumes of water and were responsible for hydro-jet handling.

A test equipment was next installed under one boiler. This equipment consisted of three primary jets with three parallel streams, forming, owing to the close spacing, a water table within a cast-iron disintegrating chamber. On this the molten slag

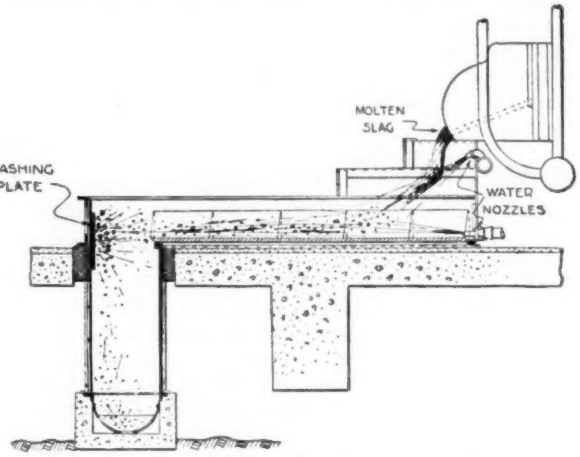


Fig. 5 Layout of the Hydro-Jet Ash-Removal System at Chas. R. Huntley Station in Buffalo, N. Y.

fell directly, being broken into small pieces and partly chilled at this point. Falling from here into a U-shaped cast-iron trough, the slag was carried crosswise of the building with the aid of two carrier jets for a distance of approximately 10 ft. and still further chilled in the process, owing to the additional cold water. This flow hit a cast-iron smashing plate, where it was turned at right angles into another U-shaped cast-iron trough running lengthwise of the building and discharging at a distance of approximately 50 ft. in the adjoining yard. Two additional carrier nozzles, working in tandem, were placed at the head end of this run. The results from this test equipment exceeded expectations. The slag was deposited in a fine granular state at the discharge of the chute.

Steps were therefore taken to provide a permanent installation but, owing to the fact that the best point for permanent disposal was about 1000 ft. from the boilers, it was necessary to pump the mixture of slag and water after discharge from the hydro-jet system. The layout decided upon is shown in Fig. 5. To meet this requirement, a pit was designed into which the sluices discharged. Two special manganese-steel pumps, each of approximately 760 g.p.m. capacity, were provided for this service and a cast-iron suction pipe was run into the discharge pit. All elbows in the suction and discharge piping are of manganese steel. One pump is intended for a spare, as both are connected in parallel to the same discharge main, which is of 6-in. steel pipe running along the side of the building and out across the adjacent land to the point of disposal. The pipe is pitched to make it self-draining and is not insulated. The material discharged spreads over a wide area and does not form a pile beneath the pipe, as had been expected.

In operation, this system has worked out as satisfactorily as on test, although it has been found desirable to increase the pressure

at the nozzles from 100 to 140 lb. in order to handle a higher rate of slag flow. These rates of flow are uncertain, being dependent upon the length of time the boiler is in service, the furnace temperature, and the prior day's firing condition.

Tapping of slag from these four boilers requires the services of two men for a period of 1 to 3 hr. daily. The quantity of water pumped depends more upon the time required than upon the actual weight of slag removed, as it is necessary to provide enough water during the early stages of tapping to care for the maximum flow that may be encountered and this is a somewhat indefinite quantity on account of the standby peak-load operation of the station. The slag may vary from a mere trickle to a 6-in. diameter stream, coming fastest just after the flow is established and decreasing in amount as time progresses. When the flow decreases, the pressure at the jets may be throttled down as experience dictates.

The original article describes a similar installation at the Toronto Station of the Pennsylvania-Ohio Power and Light Co. where the same method has been successfully employed. (*Power Plant Engineering*, vol. 33, no. 12, June 15, 1929, pp. 686-690, 3 figs., *d*)

Utilization of the Heat Energy of the Seas

THE project formulated some two or three years ago by the French engineer and inventor, Georges Claude, of producing power by making use of the difference of temperature between the surface layer of the seas and the colder deeper layers, has received considerable publicity.

Claude installed at Ougrée an experimental plant in which he claims to have confirmed the correctness of his theory and to have demonstrated to some extent its practicability. He is now engaged in a transfer of his installation to Cuba to be tried under nearly commercial conditions.

The pipe by which the water will be brought up from the sea bottom is already under construction in France. It will be 2 m. (78 in.) in diameter, which is much larger than is necessary for the small experimental plant. Such a large diameter has been selected, however, in order to determine what troubles may occur in placing the pipe and maintaining it in service conditions. The length of the pipe is to be of the order of 2000 m. (6560 ft.) which will permit it to reach a depth of 600 m. (1968 ft.) at 1500 m. (0.93 mile) from shore. As the pipe must be very light it was built of sheet iron of 2 mm. (0.078 in.) in thickness, except the reinforced part at the landing end. Corrugated sheet will, however, be used, and this is expected to increase materially resistance to crushing and to give the pipe a certain longitudinal flexibility which will help to adapt it to irregularities of the sea bottom. The latter, however, have been found not to be as bad as was feared at first. No effort was made to employ a metal that would resist corrosion. This factor was neglected as it is not expected that the experimental unit will be in operation for more than a few months. On the other hand, the pipe carries heat insulation to prevent materially heating of the ascending column of water. The part of the pipe from shore down to 25 m. (82 ft.) depth is to be protected against the action of the waves. The Ougrée installation is being dismantled and will be shipped shortly to Cuba.

When it came to a question of selection of a location in Cuba, unexpected difficulties arose. At first it was thought that the pipe could be sunk anywhere near Havana, but this did not prove to be the case. In order to find the proper location Claude bought a 500-ton yacht *Jamaica* driven by a triple-expansion 450-hp. engine. This yacht was equipped with all kinds of apparatus necessary to take depth soundings, measure temperature, and determine submarine currents. This part is under the direction of Mr. Idrac, instructor of the Polytechnic School and director of the Trappes Observatory. Of particular interest, as far as the instruments above referred to are concerned, is the apparatus invented by Idrac himself for measuring submarine currents. This instrument records photographically the revolutions of a small mill operated by the currents to be measured.

The reason that the places near Havana cannot be used is the presence of coral growth on the sea bottom, which gives the latter an irregular shape. This forced a change of plans with the result that the pipe will have to go straight down into the deep and as a result will be subjected to the full action of submarine currents that Claude wanted to avoid. He has, therefore, instituted a search for a place where the action of such currents would be very small or nil, and he believes that he has found such a place in the Matanzas Bay, about 100 km. (62 miles) to the east of Havana. The location selected is on the west coast of the bay. At 600 m. (1968 ft.) depth a temperature of 10.5 deg. cent. (50.9 deg. fahr.) has been found. The essential feature of this location is that the submarine currents in the bay seem to be very weak. If everything goes right, Claude stated at the beginning of February, the pipe would be set down about some time in June. A trouble which he fears most is formation of a foam during boiling, because of the viscosity of sea water. If, however, the enterprise does not run into disastrous troubles and the tests confirm the expectations, a unit of 12,000 kw. of useful output will be attempted. (Georges Claude. Paper before the French Academy of Sciences, abstracted through *Comptes Rendus des Seances de l'Academie des Sciences*, vol. 188, no. 6, pp. 431–435, *d*)

Circulating-Water Installation and Submarine Cables

IN CONNECTION with the installation of the Newport electricity undertaking on the River Usk near the Bristol channel in England, two interesting problems had to be solved: one to provide cooling water from condensers with a river supposed to be too small to give enough water, and the other to transfer the power from one side of the river to the other. These problems were solved in the following manner.

Until recently cooling towers were the only means available for providing the necessary circulating water for condenser cooling purposes, but as a result of exhaustive experiments carried out with the approval of the electricity commissioners, it was ascertained that the River Usk was entirely suitable for this purpose, although it had always been assumed in the past that such was not the case. To enable the experiments to be carried out, an experimental pumping station, now known as "No. 1 Pumping Station," was installed and is at present in continuous operation, its capacity being 300,000 gal. per hr. So satisfactory were the results obtained that the Newport council unhesitatingly adopted the report and recommendations of Mr. A. Nichols Moore, their borough electrical engineer, and the electricity commissioners laid it down that all future circulating-water requirements for the power house should be provided from the River Usk. To enable this to be done a large pumping station has been added to No. 1 pumping station. The construction of this second pumping station involved a number of civil and mechanical engineering difficulties, which have been successfully overcome. The River Usk in the vicinity of the power house has a maximum tidal range of 33 ft. at ordinary spring tide, but at certain seasons of the year this is very much increased. The highest recorded tide is +28.00 and the lowest —13.50, and these levels were used in designing the new pumping station.

The following brief general outline of the scheme may be of interest. It consists of the construction of an intake sump in the river, with twin culverts 42 ft. in length connecting the intake to the pumping station, which is built into the river bank, and contains an intake chamber, four screen chambers, and two pump chambers. To enable the pumping station to be constructed a

steel caisson was built upon a prepared and levelled site on the river bank, and as the caisson was gradually sunk into the bank, the concrete walls of the pumping station were formed. The caisson measured 47 ft. by 48 ft., and had a working chamber 8 ft. high, with two connections in the roof for attaching the shafts, by means of which the excavation was removed when the caisson was under air pressure.

At first very little headway was made owing to the constant flooding of the working chamber, and it was decided to erect air locks and work under continuous air pressure. Unfortunately, during the period of sinking the caisson very considerable movement of it took place riverwards, and this gave rise to great anxiety, as it was essential that the caisson in its finished position should project beyond the wharf line of the harbor commissioners. It was decided to carry on work continuously day and night, including week-ends and holiday periods, and ultimately the creepage riverwards was stopped, the caisson being founded on the mark at a level of —36.50 and the working chamber sealed with concrete and grouted up with cement. On the top of this concrete chamber the pump-house building was subsequently erected.

In order to provide the necessary pool at dead-low water and to insure that there should be no appreciable rise in temperature in the river in the vicinity of the power house, it was essential to construct a discharge well and spillway further down the river, and this work is now proceeding, a temporary discharge in the meanwhile being used. The two pump chambers are designed to take a total of four units consisting of vertical-spindle centrifugal pumps, and two units manufactured by Worthington-Simpson, Ltd., are now installed, each having a capacity of 1,000,000 gal. per hr. against a head of 76 ft. They are driven by 550-b.hp. G.E.C. motors at 320/520 r.p.m. fixed at the pump-room floor level.

Screening plants manufactured by Babcock and Wilcox, Ltd., have been installed in two of the screen chambers and consist of 48-in. band screens, each capable of dealing with the necessary quantity of water under the lowest tide-level conditions, together with all necessary auxiliary plant. An interesting feature is the provision of penstocks in the screen chambers so as to enable any particular screen chamber to supply water to any individual pump. The ultimate capacity of the pumping station is not less than 5,000,000 gal. per hr., and under low-tide and dry-weather flow conditions it has been ascertained that there will be ample water in the river to provide for this capacity.

An interesting feature in connection with the distributing system is the submarine-cable scheme, which connects the power house on the eastern side with the western side, where a very large proportion of the industrial demand is situated. For this reason it was necessary to provide ample underground feeder capacity between the east power station and the western side of the river; and to avoid the heavy cost of laying underground trunk feeders over Newport Bridge and around into the western district, it was decided to lay down in the river four extra high-tension 6000-volt submarine cables, together with pilot and telephone cables. These submarine cables are connected with the underground feeders at either end in disconnecting chambers provided with selective link gear, and, to provide for the possibility of increased transmission pressure at some future date, the cables were designed for an ultimate working pressure of 11,000 volts. The submarine-cable scheme involved very serious engineering considerations and great difficulties, but these were all successfully overcome, and the scheme carried out and completed well inside the contract period.

To enable the high-tension supplies from the East power station to be stepped down and delivered for general purposes throughout the electricity area, a large number of static substations have been erected in which the 6000-volt supplies are transformed down to 200/230 volts as may be required. In addition there are now being installed a number of kiosk transformer substations in the more outlying districts where development is taking place, and ample area has been acquired to provide sites for the kiosk transformer substations and to enable permanent substation buildings to be erected later where necessary. (*The Electrician* (London), vol. 102, no. 2661, May 31, 1929, pp. 638–641, illustrated, *dp*)

Protection of Arches and Walls of Boiler Furnaces by Molten Ashes

After considering several methods of protecting the furnace walls of pulverized-coal-fired furnaces, the author presents a method of his own which consists essentially of providing the water tubes of boiler furnaces with either fins or ribs that hold a certain amount of ash, this ash constituting an effective protection of the tubes themselves against the action of radiant heat, but at the same time causing only a very small loss of heat.

Of course, the fins or ribs have to be sufficiently cooled in order not to melt or burn away. Hence, the amount to which they can project from the tube is limited to the extent to which the water tube provides cooling, this limit depending on the quality of the metal, its heat conductivity, shape of the piece, and the weld by which they are attached. Vertical tubes, as in Fig. 6, would be equipped with fins, while strongly inclined tubes with ribs, the latter having a better heat conductivity than the former. The author describes also tube shapes, some of them with double fins, which can be used with various kinds of walls and arches. Among other things the use of such tubes permits new shapes to the combustion chamber of the furnace. Three such

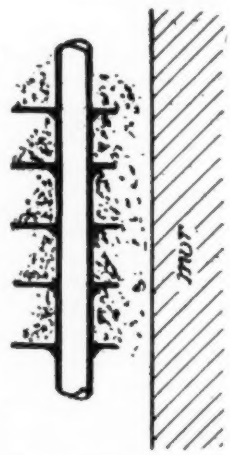


Fig. 6 Vertical Tube With Fins to Retain Ashes (*Mur* = wall)

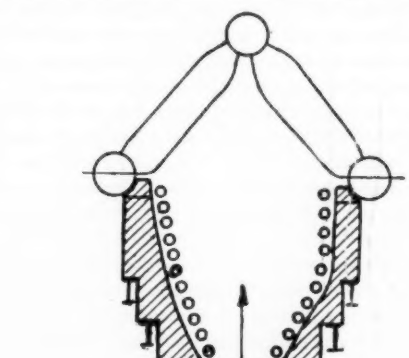


Fig. 7 V-Shape Pulverized-Coal Furnace Using the Device Shown in Fig. 6 (*Bruleur* = burner)

shapes are shown in the original article. One in Fig. 7 gives the furnace a V-shape with the walls inclined. The flame travels from bottom to top with the section increasing in such a manner that the velocity of the flame when it arrives at the tubes is small. The result is that the ashes fall back on the walls in a direction

opposite to that of the flame. This kind of furnace could not be employed with refractory walls because of the trouble that would arise from the ashes sticking to the walls.

When it is desired to use a reversed flame, which is particularly convenient with coal having a high ash content, the author recommends a design in which the flame is forced to go down quite low, while there is a double wall in the middle of the combustion chamber of the furnace having naturally a high temperature and acting as a powerful steam generator. He also shows still another arrangement in which the flame starts at the bottom, rises to the top over a bridgewall, and goes down again. With the top of the furnace protected, this permits a long flame circuit with a comparatively low boiler. This arrangement is claimed to be suitable for certain classes of furnaces, or for water-tube marine boilers. (Jules Deschamps in *Chaleur et Industrie*, vol. 10, no. 109, May, 1929, pp. 230-232, 7 figs., *d*)

REFRIGERATION

Leakage of Heat into Ships' Holds

AS HAS been seen, the rate of leakage is affected by other factors besides the nature and thickness of the insulation, and in order to provide a convenient standard of comparison the results have been expressed empirically for each part of the ship in terms of the leakage per unit area of exposed surface, quite irrespective of the thickness or material of insulation. For this purpose it has been assumed that the rate of leakage has varied directly with the difference in temperature between outer and inner surfaces, as it does when the insulation is uniform, and "coefficients of leakage" have been calculated giving the rates in B.t.u. per hour per square foot of surface for a temperature difference of 1 deg. fahr. The results are, of course, strictly valid, even for this particular vessel, only for the temperature conditions in which they were obtained, though, in view of the approximate constancy of both the external and the internal temperatures, the assumption made in the calculations that the leakage varied with the difference of temperatures can have caused no great error.

The coefficients of leakage have accordingly been calculated by dividing the amount of heat abstracted in B.t.u. per hour from each space by the total products of each of its boundary surfaces and the difference between external and internal temperatures. These figures have been corrected in each case for the change in temperature during the period of approximate equilibrium and also, where the further correction is of any significance, for the small amount of leakage between adjacent refrigerated spaces which were not at exactly the same temperature.

These coefficients disclosed certain interesting differences between the leakage into different spaces. For the upper 'tween decks they varied between 0.12 and 0.14, and for the main 'tween decks between 0.07 and 0.09; that is to say, the leakage into the upper 'tween decks was about half as much again per square foot of surface as into the holds, and between twice and three times as much into the main 'tween decks. A probable explanation for these discrepancies is suggested in the fact that the coefficient of leakage takes no account of the influence of the leakage of heat along the uninsulated upper surfaces of the decks in the 'tween-deck spaces. The omission of this effect at once explains the difference in the rates of leakage into the upper and main 'tween decks, the latter having a much smaller area of insulated surface exposed, and therefore showing a greater coefficient of leakage for a given amount of heat conducted through the decks. If, further, an allowance is made for this factor to the extent of about 65 B.t.u. per hour per foot length of the periphery of the deck exposed to warm temperatures, the coefficients of leakage all become about 0.08; the reasons are given to show that this allowance is not unreasonably large.

When this correlation has been made the rate of leakage remains still from two to three times as great as that which would occur through a uniform wall of granulated cork 10 in. thick, with a difference in temperature between its outer and inner surfaces equal to that between the external and internal spaces in these observations. This difference is attributed primarily to the leakage of heat through the steel frames, beams, and stiffeners, which extend into the insulating material, and to a less extent through the wooden grounds by which the material is held in place. That these elements of construction may have such an effect is shown by a few simplified calculations, from which it appears that in some cases the presence of such structures may result in the rate of leakage through the surface as a whole being increased by as much as three times.

Certain difficulties in the way of measuring the heat losses in ships' holds are discussed and the methods used briefly described. (Report on Leakage of Heat into Ships' Insulated Holds, published by the Department of Scientific and Industrial Research as Food Investigation Special Report No. 34, abstracted through *The Times Trade and Engineering Supplement*, vol. 24, no. 570, June 8, 1929, p. 307, *e*)

SPECIAL MACHINERY

German Cluster Mills

IT IS said that a new type of cluster mill has been developed in Germany and the original article includes a photograph of it which, however, shows no details. It is stated that the big backing up rolls are placed in roller bearings, while the small working rolls have no bearings but are being kept in position by the backing up rolls. In this way, the new mills do not differ from the standard type.

It is claimed that this type of machine has been found capable of rolling brass strip 8 in. wide and 0.060 in. thick into strip 0.017 in. thick in two passes and without intermediate annealing. Normal two-high mills for this type of work generally require at least four passes and one intermediate annealing to accomplish the same result. Strip of $4^1/_2$ in. wide has been rolled in three passes from 0.024 in. to 0.0045 in. without any intermediate annealing, whereas on normal two-high mills seven passes at least are necessary with three annealings. *Brass World and Plating Polishing-Finishing*, vol. 25, no. 5, May, 1929, p. 110, 1 fig., *d*)

Copper-Wire-Making Machinery

IT IS CLAIMED that in a plant of the Western Electric Company, changes in machinery have resulted in giving a greater wire output from a smaller plant. One of the features of this installation is that the metal is worked harder than usual, particularly on the earlier passes. With this in view rod machinery and equipment were planned for 16 instead of the usual 18 passes. Last-minute improvements permitted the final use of 14, bringing about a 22.2 per cent saving.

It has been thought that more passes bettered the physical condition of the wire rod, the industry's theory being that stronger and better wire resulted. The engineers took $^1/_4$-in. rod, converted it into wire under three exactly similar sets of conditions simultaneously, and tested the resulting product.

Two lots, 18 passes, averaged 37.9 per cent elongation, 32,599 lb. tensile.

Two lots, 16 passes, averaged 38.55 per cent elongation, 32,314 lb. tensile.

One lot, 14 passes, showed 42 per cent elongation, 32,391 lb. tensile.

The five lots averaged 39.5 per cent elongation, 32,343 lb. tensile.

The lot with the fewest passes (14) was superior in elongation (42 compared with 39.5) and above the average in tensile strength. Taking the average of the first four, the superiority of the 14-pass lot would be even greater and more apparent. In combination with fewer passes on the rod, the dies per machine in the wire drawing were increased and the machines speeded. This resulted in greater output per unit, while grouping of more dies in each unit markedly decreased the sizes of the machines. The output per floor-space unit became much greater, so that more wire has been produced from less space. Despite use of the basement, this has brought a large cut in building cost.

Another feature of this plant is that the electrical units were placed in the basement. The rollers merely push buttons to start and stop the machinery, while the electrical men in the basement neither know nor see anything of the wire machinery above. (Morris A. Hall in *Western Machinery World*, vol. 20, no. 4, April, 1929, pp. 137–138, illustrated, *d*)

SPECIAL PROCESSES

Pre-Mixed Concrete in Cincinnati

WITH the advent of Abram's water-cement ratio theory for the design of strength concrete, the central mixing plant on a commercial basis has come into existence. It is true that concrete had been poured from central plants and transported by truck or rail quite a few years ago, but the practice was not universal because of inadequate transporting equipment and a limited knowledge of the proper proportioning of concrete. It was not until about four years ago that strictly commercial plants began operating.

The central concrete-mixing plant is still in its pioneer days, but is having a rapid growth. It is being recognized as a necessary addition to the industries of any fair-sized community. All the large equipment companies are adding central mixing plant equipment to their line of products and more than a dozen different types of concrete transporting vehicles are now on the market.

Many problems arise in establishing and building a central mixing plant. The first and most important is plant location. The plant should be located in the geographic center of the future building development of any city. Adequate rail facilities and ready access to the source of supplies are essential.

Next in importance is the choice of transporting equipment. To haul concrete of any consistency satisfactorily and economically for long distances, an agitator truck of a high-speed type mounted on pneumatic tires is essential.

To operate a central mixing plant economically the design and plant layout are of vital importance. The plan should be so arranged as to handle materials rapidly at low cost. To do this the equipment must be well designed so that all units are of the proper type, size, and capacity to make a well coordinated operation for the production of concrete on a profitable commercial basis.

The Cincinnati plant consists of a bucket elevator 65 ft. high fed by a reciprocating plate feeder located under the track. The elevator can be discharged through a swivel spout into any one of four standard Blaw-Knox, 18-ft. diameter, circular, self-cleaning bins each having a capacity of 300 tons. One size of sand and three sizes of gravel are stored in them for reserve supply. Material is fed from the circular bins by gravity on to a 16-in. belt conveyor, 185 ft. long, inclined at an angle of 22 deg., which carries it to the top of a 200-ton four-compartment batching bin. The four compartments are charged from the belt through a swivel spout. The four sizes of materials are made available for instant batching. Under each compartment there is a 2500-lb. weighing batcher. This discharges directly into a stationary mixer hopper which feeds the mixer by gravity. A 56-S Ransome mixer used mixes a full 2-yd. truck load at one time.

The cement is handled in bulk from the cars by means of a power scraper and bucket elevator which elevates it to a totally enclosed circular cement bin 15 ft. in diameter with a capacity of 587 barrels. It discharges into a 2000-lb. cement weighing batcher. From the batcher the cement is carried to the mixer hopper by a screw conveyor.

The water is measured in a water tank of latest design manufactured by the Ransome Concrete Machinery Co. It is calibrated in both pounds and gallons, and is so designed and constructed that the water content of consecutive batches of concrete can be varied with no delay. This is very vital in the efficient operation of a central mixing plant because it is not uncommon to have four or five entirely different mixes for the same number of consecutive batches.

In order to produce a concrete of high quality in the winter time the plant is equipped with a 25-hp. vertical high-pressure boiler and a 700-gal. hot-water storage tank. The bins are lined with coils through which steam is passed in order to keep the aggregates warm. The water is heated in the 700-gal. tank by the injection of live steam. As the tank is totally enclosed the water may be heated at a pressure equivalent to the boiler pressure. When the pressure in the tank and boiler are equal no steam enters the water tank. This feature eliminates the necessity of a continuous flow of live steam into the water to keep it at the proper temperature as in the case of an open tank. No pump is necessary to feed the hot water to the metering tank because the pressure tank permits the use of water under city pressure through the entire system.

It has been found by test that this heating plant makes it possible in weather below freezing to discharge concrete from the mixer at a temperature of approximately 70 deg. Even during the most severe weather there is but very little heat lost in transporting concrete for distances of 6 or 7 miles. By taking these precautions it has been found that the concrete sets almost as rapidly in the winter time as in summer and the use of chemicals to lower its freezing point is eliminated. (Arthur C. Avril, Pres., Avril Tru-Batch Concrete, Inc., Cincinnati, Ohio, *Contractors and Engineers Monthly*, vol. 18, no. 4, Apr., 1929, pp. 237–240, 3 figs., 3 charts, *d*)

Thylox Process for Removing Hydrogen Sulphide From Gas

THIS process belongs to the class where the gas is scrubbed and free sulphide recovered. One of the features of the process is that the solution used remains clear throughout the cycle of purification of the gas. As a result the sulphur filtered from the solution is not contaminated by other solids and is equivalent to brimstone. Just what this solution is is not stated and it is only mentioned that it is of very low alkalinity. The apparatus used is the same as that required for the other sulphur recovery processes and the process is carried out in two steps: absorption of hydrogen sulphide from the gas in the absorber, and regeneration of the foul solution by aeration in the thionizer. Three types of thionizers have been used, tube, flotation machine, and pressure, the last being the newest. Some data of costs are given in the original article. The process is controlled by the Koppers Company of Pittsburgh, Pa. (*Gas Age-Record*, vol. 63, no. 18, May 4, 1929, pp. 597–600, 7 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

Silk Weighting

THE committee of the American Home Economics Association, concerned with commercial standardization and simplification, presents to the American Standards Association a request on behalf of its organization, that a conference be called of those concerned to consider the standardization of methods of determining weighting in silk and methods of labeling silk, which will give the homemaker information about the weighting in the silk yardage and silk garments which are offered for sale over the retail counter.

Standardization of Diesel Fuel Oils

ON THE recommendation of its Standardization Committee and the Council, The American Society of Mechanical Engineers has requested the American Standards Association to authorize the organization of a Sectional Committee to undertake the development of standard Specifications for Diesel Fuel Oils. The original request for this standardization was made by the A.S.M.E. Special Research Committee on Diesel Fuel-Oil Specifications.

In presenting this request the A.S.M.E. offered its services as sponsor for the project and Sectional Committee, and suggested that the American Society for Testing Materials be named as the co-sponsor should the project be approved.

Symbols for Hydraulics and Telephone and Telegraph

THE proposed American Tentative Standard Symbols for Hydraulics and Telephone and Telegraph have been submitted by the Sectional Committee on the Standardization of Scientific and Engineering Symbols and Abbreviations to the American Standards Association for approval. These symbols were developed by two of the nine Sub-Committees of this group developing symbols for Mechanics, Structural Engineering, and Testing Materials; Hydraulics; Heat and Thermodynamics; Photometry and Illumination; Aeronautics; Mathematics; Electrotechnical Symbols including Radio; Navigational and Topographical Symbols; and Abbreviations for Engineering and Scientific Terms. The A.S.A. has already approved the symbols for Aeronautics, Mathematics, and Letter Symbols for Electrical Quantities.

S.A.E. Discontinues Standards Ballots

QUICKER procedure in the final adoption of standards by the Society of Automotive Engineers will, it is believed, be effected by the action taken by the Council of that society at its April 9 meeting whereby recommendations for adoption will be ordered to publication in the S.A.E. Handbook or as otherwise provided, at the annual and semi-annual business sessions of the society. This eliminates the final letter-ballot heretofore required by the Standards Committee Regulations.

Analysis of a careful record of the results of all standards letter-ballots taken since March, 1918, indicates that at no time in that period has a standard been rejected by a ballot on final adoption. The average number of ballots returned by members during that period equals about 10.5 per cent of those sent out, the highest return being 19.7 per cent and the lowest 6.1 per cent. The average number of negative votes on a given subject has not exceeded 1 per cent of the number of ballots cast, or approximately 0.1 per cent of the number of ballots sent to the members.

The greatest advantage resulting from the change will be that the annual edition of the S.A.E. Handbook, or the semi-annual supplement thereto, can be sent to the members approximately four weeks earlier than heretofore when the letter-ballot was required.

The practice of publishing all Standards Committee recommendations in the *S.A.E. Journal* and circulating them widely by mail will be continued, so that all members of the society and others who are interested will have ample opportunity to review proposed standards and have a voice in their formulation before they are finally approved at the annual and semi-annual meetings.

The present regulations of the Standards Committee, Article V, paragraphs (t) to (w) inclusive, printed on p. 573 of the 1929 issue of the S.A.E. Handbook, will be revised to conform to the more expeditious procedure approved by the Council.

New American Standards Association Year Book

IMPORTANT developments in the national standardization activities of almost every major American industry are described in the American Standards Year Book, a review of the national industrial standardization movement during the past twelve months published recently by the American Standards Association, 29 West 39th Street, New York. The review covers mechanical, electrical, building, transportation, mining, textile, and many other industries.

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the month of July 15–August 15, 1929:

Electric Wiring and Apparatus in Relation to Fire Hazard, Regulations for. (National Electrical Code.)

Dimensions Governing Fit of Four-Pin Vacuum Tube Bases, and Arrangement of Terminals. (American Tentative Standard.)

Hydraulics, Symbols for. (American Tentative Standard.)

Telephone and Telegraph Use, Symbols for. (American Tentative Standard.)

Outlet Boxes, Specifications for. (American Tentative Standard.)

White Pigments, Methods of Routine Analysis of. (American Tentative Standard.)
Submitted by American Society for Testing Materials.

Dry Red Lead, Methods of Routine Analysis of. (American Tentative Standard.)
Submitted by American Society for Testing Materials.

Robert P. Lamont, U. S. Secretary of Commerce, in a foreword to the Year Book says:

The continued growth of interest at home and abroad in industrial standardization reflects its increasing importance in the world's commerce.

Through its application, the economies of mass production are rapidly extending to consumer goods, resulting in the wider distribution and consumption of many of those hitherto classed as luxuries.

The exchange of goods between countries will be facilitated by standardization international in character. As this exchange is perfected there will be an advance in world living standards, through the increased diffusion of wealth.

The American Standards Association plays a most important part in this development by serving as the agency through which American industry and business cooperate in the formulation and promotion of standards.

Its possibilities for further service in this direction fully warrant the continued and enlarged support of American industry.

New Standards and Projects

Important new standards completed under the auspices of the American Standards Association during the past year include: a group of 19 specifications and methods of test for various petroleum products; a comprehensive code for protection against lightning, including sections for protections of persons, of buildings and miscellaneous property, and of structures containing inflammable liquids and gases; standard track gages and car sizes for metal mines; a group of six specifications for bare and insulated copper wire (this is the first time that standard specifications for cotton, silk, and enameled magnet wire have been available); two more standards for pipe flanges and fittings; and specifications for track work, covering material for both steam and electric railways.

Important new projects initiated include: specifications for pressure and vacuum gages; specifications for leather belting; specifications for materials and workmanship for plastering; specifications for coal mine cars; and a comprehensive code on mine timbering, including specifications for timber and a code of timbering practice.

Results of Industrial Standardization

The following are listed in the book as the most important results of industrial standardization:

1 It enables the buyer and seller to speak the same language, and makes it possible to compel competitive sellers to do likewise.

2 In thus putting tenders on an easily comparable basis, it promotes fairness in competition, both in domestic and in foreign trade.

3 It lowers unit cost to the public by making mass production possible, as has been so strikingly shown in the unification of incandescent lamps and automobiles.

4 By simplifying the carrying of stocks, it makes deliveries quicker and prices lower.

5 It decreases litigation and other factors tending to disorganize industry, the burden of which ultimately falls upon the public.

6 It eliminates indecision both in production and utilization—a prolific cause of inefficiency and waste.

7 It stabilizes production and employment by broadening the possible market and making it safe for the manufacturer to accumulate stock during periods of slack orders to an extent which would not be safe with an unstandardized product.

8 By focusing on essentials, it decreases selling expense, one of the serious problems of our economic system.

9 By concentrating on fewer lines, it enables more thought and energy to be put into designs, so that they will be more efficient and economical.

10 By bringing out the need of new facts in order to determine what is best, and to secure agreement on moot questions, it acts as a powerful stimulus to research and development—and it is thus in decided contrast to crystallization resulting from fixity of mental attitude.

11 It is one of the principal means of getting the results of research and development into actual use in the industries.

12 It helps to eliminate practices which are merely the result of accident or tradition, and which impede development.

13 By concentration on essentials, and the consequent suppression of confusing elements intended merely for sales effect, it helps to base competition squarely upon efficiency in production and distribution and upon intrinsic merit of product.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in Mechanical Engineering.

Below are given records of the interpretations of the Committee in Cases Nos. 621, 628, and 629, as formulated at the meeting on June 21, 1929, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

Case No. 621

Inquiry: When the flange of a dished head is turned off in order to make a close and accurate fit in the shell, is it necessary to order heads thicker than required by the formula in Par. P-195 in order that the flange may not be reduced in thickness below that required by the formula?

Reply: It is the opinion of the Committee that the flange of an unstayed dished head may be reduced by machining to a thickness of not less than 90 per cent of that required for a plain head.

Case No. 628

Inquiry: Is it permissible to use less than three gage cocks on small-size waterleg-type power boilers? The boilers in question are of 1 hp. capacity with a 12 by 24 in. vertical waterleg and threaded horizontal field tubes.

Reply: Par. P-294 of the Code permits the use of only two gage cocks on locomotive-type boilers not over 36 in. in diameter. It is the opinion of the Committee that any firebox or waterleg-type boiler in which the heating surface does not exceed 50 sq. ft. need not be equipped with more than two gage cocks. A revision of Par. P-294 is under consideration to cover this feature.

Case No. 629

Inquiry: Will it meet the requirements of Par. P-325 of the Code if lugs are autogenously welded to the sides of h.r.t. boilers not exceeding 36 in. in diameter and 10 ft. long, such boilers to be installed in steel housings? The lugs would be made of steel angles of any size specified.

Reply: Par. P-325 is specific in its reference to the use of rivets or studs for the attachment of lugs or hangers used for the support of boilers. It is the opinion of the Committee that the use of fusion welding for this purpose would not meet the requirements of this paragraph.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Cleveland Hospital Disaster

To the Editor:

Editorials in Mechanical Engineering and also in the *Engineering News-Record* concerning the Cleveland Hospital disaster have overlooked the fact that there is already set up in the city an agency responsible for allowing the existence of hazardous conditions. On the other hand, both editorials decry the lack of precaution and poor management that apparently existed in the hospital. Such conditions will ordinarily not be prevented unless there is some agency responsible for finding and correcting them. This agency in Cleveland is the fire department.

It falls to the lot of fire departments to carry on not only fire-prevention work but also work of preventing disasters, calamities, etc. For example, the fire-prevention inspector will not only look for hazards which may cause fire but he will also attempt to discover dangerous conditions which may take life and destroy property.

The bureau of buildings has an allied function to that of the fire-prevention bureau of the fire department. The work of the two overlap in many instances. In the case of Cleveland it might be said that both of these agencies are responsible for both are to be found in that city government.

The prime object of both the fire-prevention bureau and the bureau of buildings is to prevent disasters and whenever disasters do occur, then they have failed in their purpose. In other words, the mere fact that hazardous conditions existed in the Cleveland Hospital is not only a fault of the hospital itself but is primarily a fault of these two departments of the City of Cleveland. They are the ones who are expert along this line—they are the ones who should know—apparently they are the ones who did not know.

May the city government of Cleveland, as well as other cities, learn from this catastrophe the fact that they have responsibility in the prevention of the existence of hazardous conditions.

Harold A. Stone.[1]

Los Angeles, Calif.

Control of Boiler-Water Treatment to Prevent Embrittlement

To the Editor:

In his article on the above subject on page 366 of Mechanical Engineering for May, Dr. F. G. Straub has ingeniously converted an otherwise useless colorimetric test into a method that promises to become a valuable one in the boiler-room control of phosphate treatment. Laboratory methods for the determination of phosphate have been entirely too complicated to admit of adaptation to plant control where a large number of boilers are to be tested at frequent intervals. While Dr. Straub's method would not be suitable at all for laboratory determinations due to its lack of accuracy, it does have the advantages of rapidity, simplicity, and sufficient differentiation for application by boiler operators. With increasing attention being brought to the phosphate methods of treating boiler feedwater, not only for the prevention of scale formation and corrosion but, in the light of Dr. Straub's more recent discoveries, to avoid cracking of boilers from caustic embrittlement, rapid control tests are becoming more desirable.

Although the new test is a colorimetric one, it is very difficult to estimate values with any degree of accuracy. For instance, when using standards of 20 and 40 p.p.m., an unknown sample containing 30 p.p.m. can scarcely be distinguished from the 40 standard, but is sharply different from the 20, and values above 40 show little distinction. Small amounts of phosphate can be detected.

However, with these limitations in mind and with adjustment of the concentration of the standard phosphate solution to the desired maximum and minimum values, a suitable control of phosphate treatment can be established.

The following table gives the amount of dry monopotassium phosphate to be used in one liter of standard solution to obtain various minimum and maximum limits:

Gram	Min. p.p.m.	Max. p.p.m.	Gram	Min. p.p.m.	Max. p.p.m.
0.0358	5	10	0.2149	30	60
0.0716	10	20	0.2507	35	70
0.1074	15	30	0.2866	40	80
0.1433	20	40	0.3224	45	90
0.1791	25	50	0.3583	50	100

A. H. Moody.[2]

New York, N. Y.

Mechanization in the Army

To the Editor:

The article on "Mechanization in the Army" in the May, 1929, issue of Mechanical Engineering is a clear statement of the military problem today and is a convincing argument in favor of such procedure. The use of mechanical devices by an army will undoubtedly increase its effectiveness, and will give it all of the eight advantages listed in the summary on p. 342.

The question now arises in the writer's mind: What will happen when two perfectly, or nearly perfectly, mechanized forces meet each other? The answer is obvious: There will be a deadlock similar to the one in the World War, and the conflict will be another wearing-down process. From the engineering standpoint the wearing-down process is uneconomic, indecisive, futile, and contrary to the very fundamentals of engineering itself. Engineering is essentially the building up of structures and organizations for the use and benefit of mankind. It seems altogether useless, pathetic, and beyond reason to have engineers engage in the destroying of each other's structures and organizations, but that is apparently what some engineers propose to do today.

We may safely conclude that mechanization of armies will not bring quick, decisive relief if both combatants are mechanized. The problems of nations today and in the future must be solved by intelligent efforts to cooperate under the direction of engineering minds. Monetary, trade, and political problems can be engineered, and the writer has confidence that engineers will answer the call.

Thomas T. Mather.[3]

Paterson, N. J.

[1] Director of Research, California Taxpayers' Association.

[2] United Elec. Light & Power Co., Hell Gate Station.

[3] Industrial Fuel Representative, Public Service Electric and Gas Company. Jun. A.S.M.E.

Standardization of Ball and Roller Bearings

THE Sectional Committee on the Standardization of Ball and Roller Bearings was organized in December, 1920, with the Society of Automotive Engineers and The American Society of Mechanical Engineers as sponsors under the procedure of the American Standards Association. The Committee now consists of 13 members. Two proposals have been developed and approved by it and are now before the sponsor bodies for approval prior to submittal to the American Standards Association for final approval. They are: Proposed American Recommended Practice, "Annular Bearings," wide type, and Proposed American Standard, "Annular Ball Bearings," single-row type. A typical table of each of these proposed standards follows.

ANNULAR BEARINGS

WIDE TYPE

Proposed American Recommended Practice

Table 1—Regular Light Series

Bearing Number	Bore			Outside Diameter			Width, In.		Shaft and Housing Fillet Radii, Max.		Shoulder Height on Shaft, Min.	
	Nominal		Toler., In. +0.0000	Nominal		Toler., In. +0.0000	Nominal	Toler. +0.000				
	Mm.	In.		Mm.	In.				Mm.	In.	Mm.	In.
5200	10	0.3937	—0.0004	30	1.1811	—0.0004	9/16	—0.005	0.6	0.024	2.5	0.098
5201	12	0.4724	0.0004	32	1.2598	0.0005	5/8	0.005	0.6	0.024	2.5	0.098
5202	15	0.5906	0.0004	35	1.3780	0.0005	5/8	0.005	0.6	0.024	2.5	0.098
5203	17	0.6693	0.0004	40	1.5748	0.0005	11/16	0.005	1.0	0.039	3.0	0.118
5204	20	0.7874	0.0004	47	1.8504	0.0005	13/16	0.005	1.0	0.039	3.0	0.118
5205	25	0.9843	0.0004	52	2.0472	0.0006	13/16	0.005	1.0	0.039	3.0	0.118
5206	30	1.1811	0.0004	62	2.4409	0.0006	15/16	0.005	1.0	0.039	3.0	0.118
5207	35	1.3780	0.0005	72	2.8346	0.0006	1 1/16	0.005	1.0	0.039	3.5	0.138
5208	40	1.5748	0.0005	80	3.1496	0.0006	1 3/16	0.005	1.0	0.039	3.5	0.138
5209	45	1.7717	0.0005	85	3.3465	0.0008	1 3/16	0.005	1.0	0.039	3.5	0.138
5210	50	1.9685	0.0005	90	3.5433	0.0008	1 3/16	0.005	1.0	0.039	3.5	0.138
5211	55	2.1654	0.0006	100	3.9370	0.0008	1 5/16	0.005	1.5	0.059	4.5	0.177
5212	60	2.3622	0.0006	110	4.3307	0.0008	1 7/16	0.005	1.5	0.059	4.5	0.177
5213	65	2.5591	0.0006	120	4.7244	0.0008	1 1/2	0.005	1.5	0.059	4.5	0.177
5214	70	2.7559	0.0006	125	4.9213	0.0010	1 9/16	0.005	1.5	0.059	4.5	0.177
5215	75	2.9528	0.0006	130	5.1181	0.0010	1 5/8	0.005	1.5	0.059	4.5	0.177
5216	80	3.1496	0.0006	140	5.5118	0.0010	1 3/4	0.005	2.0	0.079	5.0	0.197
5217	85	3.3465	0.0008	150	5.9055	0.0010	1 15/16	0.005	2.0	0.079	5.0	0.197
5218	90	3.5433	0.0008	160	6.2992	0.0010	2 1/16	0.005	2.0	0.079	5.0	0.197
5219	95	3.7402	0.0008	170	6.6929	0.0010	2 3/16	0.005	2.0	0.079	6.0	0.236
5220	100	3.9370	0.0008	180	7.0866	0.0010	2 3/8	0.005	2.0	0.079	6.0	0.236
5221	105	4.1339	0.0008	190	7.4803	0.0012	2 9/16	0.005	2.0	0.079	6.0	0.236
5222	110	4.3307	0.0008	200	7.8740	0.0012	2 3/4	0:005	2.0	0.079	6.0	0.236

Table 1A—Extended Light Series

5224	120	4.7244	0.0008	215	8.4646	0.0012	3	0.005	2.0	0.079	6.0	0.236
5226	130	5.1181	0.0010	230	9.0551	0.0012	3 1/8	0.005	2.5	0.098	7.0	0.276
5228	140	5.5118	0.0010	250	9.8425	0.0012	3 1/4	0.005	2.5	0.098	7.0	0.276
5230	150	5.9055	0.0010	270	10.6299	0.0016	3 1/2	0.005	2.5	0.098	7.0	0.276
5232	160	6.2992	0.0010	290	11.4173	0.0016	3 7/8	0.005	2.5	0.098	7.0	0.276
5234	170	6.6929	0.0010	310	12.2047	0.0016	4 1/8	0.005	3.0	0.118	9.0	0.354
5236	180	7.0866	0.0010	320	12.5984	0.0016	4 1/4	0.005	3.0	0.118	9.0	0.354
5238	190	7.4803	0.0012	340	13.3858	0.0016	4 1/2	0.010	3.0	0.118	9.0	0.354
5240	200	7.8740	0.0012	360	14.1732	0.0016	4 3/4	0.010	3.0	0.118	9.0	0.354
5244	220	8.6614	0.0012	400	15.7480	0.0024	5 1/4	0.010	3.0	0.118	9.0	0.354
5248	240	9.4488	0.0012	440	17.3228	0.0024	5 3/4	0.010	3.0	0.118	9.0	0.354
5252	260	10.2362	0.0012	480	18.8976	0.0024	6 1/4	0.010	4.0	0.157	11.0	0.433
5256	280	11.0236	0.0016	500	19.6850	0.0024	6 1/2	0.010	4.0	0.157	11.0	0.433
5260	300	11.8110	0.0016	540	21.2598	0.0024	7	0.010	4.0	0.157	11.0	0.433
5264	320	12.5984	0.0016	580	22.8346	0.0024	7 1/2	0.010	4.0	0.157	11.0	0.433

NOTE.—The corner radius or chamfer on bearings must clear the maximum fillet radii given in the table and provide for sufficient bearing against the minimum shoulder on the shafts.

THE ABOVE TABLE IS ONE OF THREE MAKING UP THE PROPOSED AMERICAN RECOMMENDED PRACTICE FOR "ANNULAR BEARINGS," WIDE TYPE. TABLE 2 COVERS REGULAR MEDIUM SERIES AND TABLE 3 COVERS REGULAR HEAVY SERIES

ANNULAR BALL BEARINGS

SINGLE ROW TYPE

Proposed American Standard

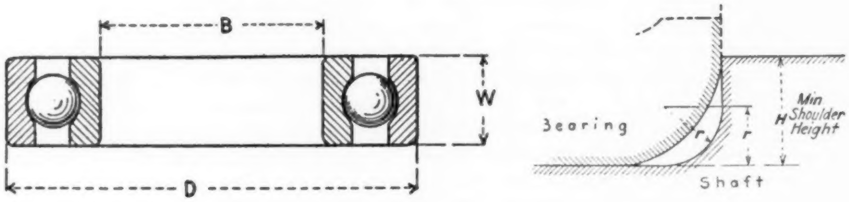


Table 1—Light Series

Bearing Number	Bore B			Outside Diameter D			Width of Individual Rings W			r Shaft and Housing Fillet Radii[1] Maximum		H Height of Shoulder on Shaft Minimum		Eccentricity Tolerances, Inches Maximum	
	Nominal Diameter		Toler., In. +0.0000	Nominal Diameter		Toler., In. +0.0000	Nominal Width		Toler., In. +0.000						
	Mm.	In.		Mm.	In.		Mm.	In.		Mm.	In.	Mm.	In.	Inner Ring	Outer Ring
34	4	0.1575	−0.0004	16	0.6299	−0.0004	5	0.1969	−0.005	0.4	0.016	—	—	0.0004	0.0008
35	5	0.1969	0.0004	19	0.7480	0.0004	6	0.2362	0.005	0.4	0.016	—	—	0.0004	0.0008
37	7	0.2756	0.0004	22	0.8661	0.0004	7	0.2756	0.005	0.4	0.016	—	—	0.0004	0.0008
39	9	0.3543	0.0004	26	1.0236	0.0004	8	0.3150	0.005	0.4	0.016	—	—	0.0004	0.0008
200	10	0.3937	0.0004	30	1.1811	0.0004	9	0.3543	0.005	0.6	0.024	2.5	0.098	0.0006	0.0012
201	12	0.4724	0.0004	32	1.2598	0.0005	10	0.3937	0.005	0.6	0.024	2.5	0.098	0.0006	0.0012
202	15	0.5906	0.0004	35	1.3780	0.0005	11	0.4331	0.005	0.6	0.024	2.5	0.098	0.0006	0.0012
203	17	0.6693	0.0004	40	1.5748	0.0005	12	0.4724	0.005	1.0	0.039	3.0	0.118	0.0006	0.0012
204	20	0.7874	0.0004	47	1.8504	0.0005	14	0.5512	0.005	1.0	0.039	3.0	0.118	0.0006	0.0012
205	25	0.9843	0.0004	52	2.0472	0.0006	15	0.5906	0.005	1.0	0.039	3.0	0.118	0.0008	0.0012
206	30	1.1811	0.0004	62	2.4409	0.0006	16	0.6299	0.005	1.0	0.039	3.0	0.118	0.0008	0.0012
207	35	1.3780	0.0005	72	2.8346	0.0006	17	0.6693	0.005	1.0	0.039	3.5	0.138	0.0008	0.0012
208	40	1.5748	0.0005	80	3.1496	0.0006	18	0.7087	0.005	1.0	0.039	3.5	0.138	0.0008	0.0012
209	45	1.7717	0.0005	85	3.3465	0.0008	19	0.7480	0.005	1.0	0.039	3.5	0.138	0.0010	0.0016
210	50	1.9685	0.0005	90	3.5433	0.0008	20	0.7874	0.005	1.0	0.039	3.5	0.138	0.0010	0.0016
211	55	2.1654	0.0006	100	3.9370	0.0008	21	0.8268	0.005	1.5	0.059	4.5	0.177	0.0010	0.0016
212	60	2.3622	0.0006	110	4.3307	0.0008	22	0.8661	0.005	1.5	0.059	4.5	0.177	0.0010	0.0016
213	65	2.5591	0.0006	120	4.7244	0.0008	23	0.9055	0.005	1.5	0.059	4.5	0.177	0.0010	0.0016
214	70	2.7559	0.0006	125	4.9213	0.0010	24	0.9449	0.005	1.5	0.059	4.5	0.177	0.0010	0.0016
215	75	2.9528	0.0006	130	5.1181	0.0010	25	0.9843	0.005	1.5	0.059	4.5	0.177	0.0010	0.0016
216	80	3.1496	0.0006	140	5.5118	0.0010	26	1.0236	0.005	2.0	0.079	5.0	0.197	0.0012	0.0018
217	85	3.3465	0.0008	150	5.9055	0.0010	28	1.1024	0.005	2.0	0.079	5.0	0.197	0.0012	0.0018
218	90	3.5433	0.0008	160	6.2992	0.0010	30	1.1811	0.005	2.0	0.079	5.0	0.197	0.0012	0.0018
219	95	3.7402	0.0008	170	6.6929	0.0010	32	1.2598	0.005	2.0	0.079	6.0	0.236	0.0012	0.0018
220	100	3.9370	0.0008	180	7.0866	0.0010	34	1.3386	0.005	2.0	0.079	6.0	0.236	0.0012	0.0018
221	105	4.1339	0.0008	190	7.4803	0.0012	36	1.4173	0.005	2.0	0.079	6.0	0.236	0.0012	0.0018
222	110	4.3307	0.0008	200	7.8740	0.0012	38	1.4961	0.005	2.0	0.079	6.0	0.236	0.0012	0.0018
224	120	4.7244	0.0008	215	8.4646	0.0012	40	1.5748	0.005	2.0	0.079	6.0	0.236	0.0014	0.0020
226	130	5.1181	0.0010	230	9.0551	0.0012	40	1.5748	0.005	2.5	0.098	7.0	0.276	0.0014	0.0020
228	140	5.5118	0.0010	250	9.8425	0.0012	42	1.6535	0.005	2.5	0.098	7.0	0.276	0.0014	0.0020
230	150	5.9055	0.0010	270	10.6299	0.0016	45	1.7717	0.005	2.5	0.098	7.0	0.276	0.0014	0.0020
232	160	6.2992	0.0010	290	11.4173	0.0016	48	1.8898	0.005	2.5	0.098	7.0	0.276	0.0014	0.0020
234	170	6.6929	0.0010	310	12.2047	0.0016	52	2.0472	0.005	3.0	0.118	9.0	0.354	0.0014	0.0020
236	180	7.0866	0.0010	320	12.5984	0.0016	52	2.0472	0.005	3.0	0.118	9.0	0.354	0.0014	0.0020
238	190	7.4803	0.0012	340	13.3858	0.0016	55	2.1654	0.010	3.0	0.118	9.0	0.354	0.0014	0.0020
240	200	7.8740	0.0012	360	14.1732	0.0016	58	2.2835	0.010	3.0	0.118	9.0	0.354	0.0014	0.0020
244	220	8.6614	0.0012	400	15.7480	0.0024	65	2.5591	0.010	3.0	0.118	9.0	0.354	0.0018	0.0024
248	240	9.4488	0.0012	440	17.3228	0.0024	72	2.8346	0.010	3.0	0.118	9.0	0.354	0.0018	0.0024
252	260	10.2362	0.0012	480	18.8976	0.0024	80	3.1496	0.010	4.0	0.157	11.0	0.433	0.0018	0.0024
256	280	11.0236	0.0016	500	19.6850	0.0024	80	3.1496	0.010	4.0	0.157	11.0	0.433	0.0018	0.0024
260	300	11.8110	0.0016	540	21.2598	0.0024	85	3.3465	0.010	4.0	0.157	11.0	0.433	0.0018	0.0024
264	320	12.5984	0.0016	580	22.8346	0.0024	92	3.6220	0.010	4.0	0.157	11.0	0.433	0.0018	0.0024

Note 1—The corner radius or chamfer on bearings must clear the maximum fillet radius given in the table and provide for sufficient bearing area against the minimum shoulder on the shafts.

Conversion from metric to decimal inch dimensions is according to the formula 1 mm. = 0.0393700 inch.

Bearing numbers and eccentricity tolerances are not intended for inclusion in the proposed international standard.

Corrected May 22, 1929

THE ABOVE IS TABLE 1 OF THE PROPOSED AMERICAN STANDARD FOR "ANNULAR BALL BEARINGS," SINGLE ROW TYPE. TABLE 2 COVERS MEDIUM SERIES AND TABLE 3, HEAVY SERIES

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK, *Aeronautic Division*	*J. L. WALSH,* *National Defense Division*
A. L. KIMBALL, JR., *Applied Mechanics Division*	*L. H. MORRISON,* *Oil and Gas Power Division*
H. W. BROOKS, *Fuels Division*	*W. R. ECKERT,* *Petroleum Division*
R. L. DAUGHERTY, *Hydraulic Division*	*F. M. GIBSON and W. M. KEENAN,* *Power Division*
WM. W. MACON, *Iron and Steel Division*	*WINFIELD S. HUSON,* *Printing Industries Division*
JAMES A. HALL, *Machine-Shop Practice Division*	*MARION B. RICHARDSON,* *Railroad Division*
CHARLES W. BEESE, *Management Division*	*JAMES W. COX, JR.* *Textile Division*
G. E. HAGEMANN, *Materials Handling Division*	*WM. BRAID WHITE,* *Wood Industries Division*

Fuels

Economics of Pulverized-Coal Firing on Railroads

F-10 What have been the best economical and operating results actually obtained to date in regular train operation of pulverized-fuel-fired locomotives?

In a symposium now being published by the National Coal Association entitled "Powdered Coal and the Coal Industry" (second edition), John E. Muhlfeld, Consulting Engineer, New York City, is quoted as follows:

"Kansas City Southern Mallet articulated compound, No. 766, 2–8–8–0 type, locomotive, which has 145,200 lb. tractive power in simple gear, and 122,683 lb. tractive power in compound gear, operating between Pittsburg, Kans., and Heavener, Okla., on a continuous 209-mile run, or 418 miles per round trip, is a good example.

"During the round trip, it is handled by four different engine crews. It is equipped with self-contained unit system of coal pulverizing and burning equipment for burning powdered bituminous slack in suspension, and fuel oil for firing either separately, or both fuels at the same time.

"The coal used is 1-in. slack, about 80 per cent of which will pass through a $^1/_2$-in. mesh screen, and analyzes about as follows:

Moisture, per cent	2 to 4
Volatile, per cent	12 to 19
Fixed carbon, per cent	73 to 78
Ash, per cent	7 to 10
Sulphur, per cent	1
B.t.u. per lb	13,000 to 13,250

"The cost is $1.75 per ton and similar coal of run-of-mine grade would cost between $3.15 and $3.40 per ton. It is pulverized on the tender as used.

"The actual saving in coal consumption on the basis of 1000 gross ton-miles hauled is between 23 and 29 per cent, as compared with hand firing and burning coal on grates, and in addition, the steaming capacity of the locomotive is brought up to that of an oil burner.

"Fuel oil, which the powdered coal replaces, has a heat value of about 18,800 B.t.u., and costs $1.15 per bbl. of 42 gallons. On the basis of these comparative fuel heat values and prices, the cost for locomotive fuel per thousand gross ton-miles will average about 10 cents for the coal and 25 cents for the oil. Fuel saving per round trip of 418 miles approximates $165, or about $40 per 100 miles.

"This locomotive operates over 209 miles of heavy-grade line ranging from 0.5 to 2.0 per cent grades, and on the basis of 1000 gross ton-miles, including the weight of the engine, the powdered slack consumption will range from 86 to 98 lb., which gives an average of about 92 lb." (Editor.)

Acid-Erosion Inhibition

F-11 In unlined steel stacks, flues and breechings operating up to capacity, what methods have been used to inhibit acid erosion where high-sulphur coals are burned, and what results in increased life have been attained?

As the Commonwealth Edison Company uses coal from the Central Illinois fields, which is high in sulphur—about four and one-half per cent—there has never been an attempt to use unlined stacks or flues, as corrosion has always been in evidence, even when these were lined. The boiler uptakes and induced-draft fan casings which are unlined have very short lives, particularly if the boilers are operated on intermittent service and the flues are alternately hot and cold.

The soot and dust which collect on these parts act as a sponge for holding the condensation which forms when the temperature of the plates gets below the dewpoint of the gas. This is especially noticeable with Illinois coals, as they have not only a high moisture content but also considerable hydrogen.

There have been cases of stacks lined with tile, where the lining was not solidly grouted to the sheet, in which the steel continued to show up quite well as long as the boilers operated continuously, but the parts corroded very rapidly when the boilers were operated intermittently, or for peak service. At the present time, stacks and breechings are being lined with brick grouted with cement mortar, the steel having first been cleaned and painted with red lead; or else the lining is put on with a cement gun.

So far as protective paints are concerned, none of them which the writer's company has tried has aided materially in prolonging the life of the steel. (Alex D. Bailey, Superintendent, Generating Stations, Commonwealth Edison Company, Chicago, Ill.)

Petroleum

Stresses in Oil-Well Casings

PT-1 What methods are recommended for determining the types of stresses causing failure of oil-well casings at depths of 2000–3000 ft.?

It is suggested that jointed casing be placed under compression from each end, then encircled with another casing, and a hydraulic pressure created between the two for a collapsing test, also that the casing be twisted while this outside hydraulic pressure is being applied. As internal bursting strains are less than the external bursting, it would be well to run some bursting pressures. The writer understands from this question that a specific kind of test, that will indicate limits of pressures or conditions which would cause pipe to fail, operating under depths indicated, is desired. However, there appears to be no reason for limiting these tests to two to three thousand feet, as oil wells are now drilled to more than a mile in depth and the maximum stresses are at the deepest point. (H. R. Pierce, Consulting Engineer, Pittsburgh, Pa.)

Power

Steam Costs in Industrial Plants

P-2 Please publish, for the purpose of comparison, data as to steam costs per 1000 lb. of steam in industrial plants, giving in each case the cost of the fuel. The plant against which these costs are to be checked has a monthly demand of around 15,000,000 lb., and a capacity of 20,000,000 to 25,000,000 lb., the coal costing from $2.10 to $2.25 per ton, f.o.b. at the plant, and steam pressures of from 100 to 110 lb.

It is rather inadvisable to attempt to compare the cost in one plant with that in another, unless all the conditions are comparable, inasmuch as the price of fuel, the labor cost, cost of water, fixed charges, and load factor, may affect the cost of steam. In general, however, the cost of producing a thousand pounds of steam will range from 25 to 40 cents. Under very favorable conditions it may be slightly less than this and there are a large number of the more inefficient plants in which it is costing considerably more, reaching in some cases as high as 60 cents per thousand pounds.

A large industrial plant in the vicinity of New York pays slightly under $5 a ton for coal and produces steam at $27^1/_2$ cents per thousand pounds. This plant operates twenty-four hours a day, five days a week, hence the banking losses are relatively small. Moreover, it is a large plant, very well operated, and runs on pulverized coal.

A stoker-fired industrial plant of about the same size in New England, which operates at about the same load factor and which pays 10 cents more per ton for coal, turns out steam at $32^1/_2$ cents per thousand pounds.

A new plant of about 2000 hp., near Baltimore, which pays $3.67 per ton, turns out steam at around 26 cents per thousand pounds.

An industrial plant in Connecticut, the boiler room of which has recently been rebuilt, is now able to turn out steam at 25 cents per thousand pounds, with coal costing around $5.50 a ton. This is exclusive of overhead and certain of the fixed charges.

On the other hand, an office building in New York City, which has a relatively low load factor, and has been paying around 5 cents a gallon for oil, has a steam cost of nearly 60 cents per thousand pounds. In this class is a coal-fired industrial plant in Canada where the steam is costing 60 cents.

The foregoing plants, in which the steam costs range from 26 to 32 cents, represent what one might call the better grade of plants intelligently operated. These are somewhat above the average industrial plant which would come closer to 40 cents per thousand pounds of steam. (A. D. Blake, Secretary, Fuels Division, A.S.M.E.)

Miscellaneous

Cadmium-Plated Bearing Surfaces

M-7 Will cadmium, deposited on bearing surfaces in the process of plating machine parts to prevent corrosion, damage the bearing as it flakes off in operation?

It is the opinion of the engineering and laboratory staff of the Detroit office of the writer's company that a slight amount of cadmium deposited on such bearings would not have any serious effect whatever; in fact, because of its peculiar characteristics, it would have a decided lubricating effect even though the cadmium should not firmly adhere and should flake off. Even this would cause no difficulty as it would tend to flow into the low spots instead of building up and causing scoring of the shaft or bearing.

In view of these facts, the inquirer need not hesitate to plate the parts he has in mind. He can be assured that the small amount of cadmium deposited on the bearing surfaces will not cause him the slightest difficulty. (W. L. Cassell, Udylite Process Co., New York, N. Y.)

Questions to Which Answers Are Solicited

Coal for Forced-Draft and Preheat Conditions

F-12 What coal specifications are recommended for forced-draft conditions such as are encountered in Taylor stokers operating on 400-deg. preheated air?

Heat Transfer in Cooking Equipment

M-8 What is the rate of heat transfer between hot water and cooking meat in jacketed cooking equipment?

CO_2 for Manufacture of Refrigerant

M-9 What are the most common sources of carbon dioxide used in the manufacture of solidified CO_2 for refrigeration purposes?

Conveying Sand Hydraulically

M-10 It is planned to convey sand from a washer to a height of 20 feet above the washer by means of water injected at high velocity through a nozzle into a 5-in. pipe. Does this arrangement seem feasible, or will the quantity of water to be disposed of offset the advantages gained by the elimination of mechanical apparatus?

Bending a Heavy I-Beam

M-11 It is proposed to bend a 9-in. I-beam of heavy section to a radius of 11 ft., 3 in. What methods are recommended to accomplish this without destroying the shape of the web of the beam?

Leaky Boilers Following Use of Water Softeners

P-3 A user reports leaky seams and rivets following the use of softened feedwater. What may be the cause of this and what remedies are suggested?

Troubles With High Boiler Pressures

P-4 What troubles have so far been experienced with high boiler pressures on locomotives?

Developments in Long-Draft Spinning of Cotton Yarn

T-2 What are the latest developments in long-draft spinning of cotton yarn? Has any system of long-draft spinning been generally adopted in this country?

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

Stockholder Cooperation

ONE of the financiers of the ante-bellum generation at a general meeting of stockholders was said to have ordered that a vote be taken first and "let the fool stockholders ask questions afterward." With a majority of voting stock safely in his hands, probably through control of banks or insurance companies, this was a practical method of doing business quickly. Whether it was good business policy is, of course, another question. It is significant that such an attitude, while still existent, is becoming less and less general.

There are still companies whose reports are examples of a thorough lack of information, as has been pointed out eloquently by Professor Ripley in his "Main Street and Wall Street." Other companies, however, are honestly endeavoring to secure stockholder cooperation and at least make it possible for their stockholders to obtain a clear knowledge of the affairs of the company. An interesting step has recently been taken in this direction by the General Electric Company which sent out to all the stockholders a pass admitting them to any of the plants of the company at any time. It is not expected, of course, that stockholders will be permitted to view confidential research work and no one would expect it. But the mere ability to go through the plants will certainly make stockholders of the company feel differently toward their investment. With stock ownership of the large industrial organizations becoming more and more widely scattered and the number of stockholders in some of them reaching hundreds of thousands, it becomes increasingly important to secure proper cooperation between stockholders and management and to get the stockholders interested in the companies in whose securities they have invested their money. From this point of view the move of the General Electric Company appears to be a step in the right direction. Its further development will be awaited with interest.

The Bremen

IN 1889 the *City of Paris* crossed the Atlantic in 5 days, 19 hr. and 18 min. In 1928 the *Mauretania* made the journey in 5 days, 2 hr. and 34 min. In July, 1929, the *Bremen* crossed in 4 days, 17 hr. and 42 min. It would appear, therefore, that the advance in speed of transatlantic crossing since 1889, or in the last forty years, has been about 25 per cent.

Considering the great improvement in power generation during the same period one may wonder why only such a comparatively mediocre advance in speed of transatlantic travel by water has been achieved. The cause is not far to seek.

The power consumption of a vessel, all other factors being equal, increases substantially as the cube of the speed. Even a small advance in speed, therefore, is heavily paid for by increase in fuel consumption and size of the engines. If one considers this relation, an increase of 25 per cent in speed assumes really serious proportions. Furthermore, it should be clearly remembered that the present transatlantic crossing of the *Bremen* does not make it the fastest vessel on the ocean. Any modern battle cruiser can easily beat the *Bremen*, while our own aircraft carriers, *Saratoga* and *Lexington*, can play rings around the new North German Lloyd giant. But these vessels, unlike the *Bremen*, are really little more than propellers to which a big power plant enclosed in the hull is attached. There is little room provided for anything except the most vital equipment, and in the fastest military ships—torpedo boat destroyers—even safety is sacrificed to the necessity for speed (safety being used in the civilian and not the military sense of the term).

The big handicap in the way of achieving higher speeds which faces vessels of the type of the *Mauretania* and the *Bremen* lies in the fact that besides making speed they must also make money. This means that the cost of operation of the vessel, including fuel consumption, has to be balanced against the amount of money that can be taken in at the office, and in order to take in enough money to pay for the trip and leave a balance for dividends, room must be provided to house passengers under modern tremendously exacting conditions of comfort. To all practical purposes it is a question of which pays better—a few extra horsepower on the turbine or a few extra feet on the swimming pool.

This places the record of the *Bremen* in a somewhat different light. If the new ship crossed the Atlantic in nine hours' shorter time than the *Mauretania* and made money, the record is truly remarkable. If it made the trip without a profit (which means, of course, a profit on average operation and not one particular crossing), then the victory is chiefly valuable as an advertising stunt and an engineering achievement.

At the same time engineers will sincerely welcome the splendid workmanship and design which permitted this vessel to attain an unprecedented speed for its class and to do it apparently without forcing the engines or the personnel. The *Bremen* unquestionably embodies what might be called the "latest word" in ship construction, and its performance will profoundly affect the status of marine engineering from now on.

It is stated in the third paragraph of this editorial that the power consumption of a vessel, all other factors being equal, increases substantially as the cube of the speed. When we compare the *Bremen* with its nearest rival in speed, the *Mauretania*, it is important to notice that all other factors are not equal. The power consumption of a vessel increases substantially as the cube of the speed, providing the efficiency of the propeller is the same and the resistance to the translation of the vessel is also the same. As far as is known, the efficiency of the propellers of the *Bremen* does not materially differ from conventional figures. On the other hand, while no complete information on this factor is available, it is known that the designers of the *Bremen* skilfully

made use of the most recent information on resistance of fluids to the motion of solid bodies obtained in hydrodynamical and aerodynamical laboratories.

It is known on good authority that the hull of the *Bremen* has been given a very clever streamline (using this word in a special sense) shape, which materially contributed to the speed of the vessel by reducing what might be called, for the sake of simplicity, the water resistance. It would be only fair to add that since the *Mauretania* was built, very great improvements have been made in the design of steam turbines and boilers, and particularly in the details of construction of geared turbines, which have also contributed to the ability to increase the speed of the vessel without sacrificing as much space as would have been necessary to achieve the same result twenty years ago.

And What Then?

RECENTLY there have been two attempts to cross the Atlantic by air from east to west—one by French fliers who had to return to Paris, and the other by Polish fliers who crashed on an island with one man killed and the other injured. A flight across the Pacific is in preparation; and there will be probably more attempts to cross the Atlantic. Engineers will ask themselves, "What will such crossings show today in the light of recent developments in endurance testing of planes, motors, and men?"

The early flights across the Atlantic, such as those by Brown and Alcock, and particularly the flights of Lindbergh, Chamberlin, and Byrd, were in the nature of demonstrating what might be called the "reaching of majority" by the aeronautical art. The men who made these flights did something which very few people believed could be done at that time, and in this way they rendered a true service to aeronautics.

But what will it mean today if two more fliers cross the Atlantic in a plane? As this is being written, two fliers over the Lambert, St. Louis, airport have been in the air for more than two weeks, refueling, of course, their plane. The men appear to be in good physical condition, judging from the notes they are dropping from time to time. That the plane and motor are in good shape is demonstrated by the simple fact that they are staying up in the air. At the rate these fliers are going through the air they could have easily made a trip around the world in the time they have been up.

What then will a crossing of the Atlantic or Pacific show in the light of this wonderful performance? It will not prove the endurance ability of the men, as neither of the transoceanic trips will last more than about one-sixth of the duration of the St. Louis endurance test. It will not prove anything as to the planes or motors for the same reason. Now that we know that modern planes and motors are good for something like 25,000 to 30,000 miles of continuous flight, and probably a great deal more, a flight of 3000 or 4000 miles is meaningless as a test of endurance. It would appear, therefore, that today a transoceanic flight can demonstrate only the luck of the fliers. These men are betting that the supply of gasoline which they can carry will be sufficient to transport them across the ocean in the face of such weather as they may encounter. If the weather is good, they will cross. If it happens to be bad or indifferent, there will be another air tragedy or another "spectacular" rescue. With all due respect to the courage and the ability of the men that may undertake such adventures, it should be very clearly understood that the engineering value of the flights today is nil, and from now on they should be clearly relegated to the class of publicity stunts, with one important limitation, however. Sooner or later commercial operation of airplanes across the ocean will be established. This cannot be done over night and must be accomplished by a series of flights, possibly involving a certain hazard at the beginning, but gradually approaching the degree of safety which will permit a regular public service.

This means that as the size of the planes and ability of the motors increase, we shall gradually approach the stage where a plane will have a sufficient cruising radius to permit an attempt to cross such a body of water as the Atlantic, either from Africa to Brazil or from Maine to Ireland, at least with a reasonable certainty of reaching the goal even if the weather should prove to be unfavorable. When this happens, flights across the water will be in order, because there is no way of testing out Atlantic flying weather except by flying along the projected routes over the Atlantic itself. These flights will deserve the most serious attention and will, of course, be anything but publicity stunts. Just how near we are to such a state of affairs no one can tell. The indications are, however, that something of the kind will be attempted within the next twelve months.

Engineering Executives

THERE are abundant signs, to which attention is called frequently in this journal, that the field of engineering is ever broadening to include activities outside the physical sciences. The spread of industrialism, which owes its advances to engineering, has carried engineers into executive and administrative positions. Surveys of the occupations of graduates of engineering schools show that at least two-thirds of the men who study engineering soon abandon its more technical phases for managerial posts. It is only necessary to turn back a single generation to find conspicuous examples of the contributions which engineers have made to the art of management. The Society itself, whose literature is so rich in the fundamentals of this most recent field for engineering achievement, has a powerful Management Division, the number of its members being an eloquent testimony to interest in this field.

In a paper which was delivered before a management congress in Paris, Wm. L. Batt, himself a graduate engineer and executive head of a business that is typical of an engineering era, writes of the duties of an executive. There is straight-forwardness to Mr. Batt's style and sincerity and common sense to his theses which carry conviction with them. The picture which Mr. Batt has drawn commands admiration and respect. Those who occupy such positions as Mr. Batt writes about will find a frank comparison of themselves with it profitable. Those who aspire to such positions will find Mr. Batt's executive an excellent model.

At Salt Lake City

ON JULY 1 to 4, the A.S.M.E. held its first general meeting in Salt Lake City. The Society has always hesitated to put the burden of one of its major meetings on so few of its members but the enthusiasm of the engineers of Salt Lake City convinced the officers and Council that their request to be allowed to act as hosts should be granted. The meeting was a pronounced success.

The proximity of copper and coal mines made it logical to discuss the mechanical problems of the mining industry. There have already been published in MECHANICAL ENGINEERING two papers presented at Salt Lake City dealing with this problem. One of these, by H. C. Goodrich, chief engineer of the Utah Copper Co., on "Ore Handling at the Utah Copper Co. Mines and Mills," was published in June and described the methods used at this mine. Following the presentation of the paper, the mine, which is the greatest of all open-cut copper mines, was visited. The second paper, by O. G. Sharrer, assistant mine superintendent of the Union Pacific Coal Co., on mechanical

loading of coal in mine cars, was published in July. The author told how the company's mines were mechanized according to a plan which was arranged so that the introduction of mechanical equipment was accomplished without labor troubles and without throwing miners out of work.

Geo. A. Orrok and W. H. Trask, Jr., mechanical engineer, Salt Lake Hardware Co., presented a paper on the interesting problem which the city faces in its fuel supply and smoke nuisance. The smoke problem of Salt Lake City is a particularly serious one because of the local topographical features. The Society is earnestly endeavoring to put the weight of its influence behind every effort to eliminate smoke, and its meetings and literature contribute generously to the cause. While many technical problems are involved, these are generally understood by engineers. The most necessary element in the success of a campaign is favorable public opinion and this must be obtained by a clear understanding on the part of all intelligent citizens of the facts of the local situation, such as are given in the paper presented at Salt Lake City. Recent rapid growth in air-mindedness on the part of the public in this country was pointed out by P. G. Johnson, president of the Boeing Airplane Co., who said that there are 21,000 miles of established airways and 1600 airports in the United States, and predicted greater use of airplanes for carrying mail, express packages, and passengers.

Enthusiasm and hard work on the part of the local committee earned success for the meeting and demonstrated that a small group of earnest workers, located at a considerable distance from the center of industry of the country, can make use of their local resources to advantage.

Diesel Engines Discussed at State College, Pa.

Second National Meeting of A.S.M.E. Oil and Gas Power Division

On June 24 to 27, the second national meeting of the A.S.M.E. Oil and Gas Power Division was held, as was last year's meeting, in connection with the Oil Power Conference of the Pennsylvania State College at State College, Pa. Diesel engines were discussed at the meeting. This noteworthy gathering of engineers, numbering upward of 250, offers substantial proof of the benefits to be derived from the national meetings of the society and the cooperation of its professional divisions with other agencies, such as the Pennsylvania State College. The College and all of those representing it, who labored so faithfully with the Central Pennsylvania Section of the Society to make the meeting a success, are entitled to much credit, and all engineers have become their debtors because of their fruitful efforts.

The first day of the conference was devoted to the high-speed oil engine. Great interest naturally attaches to attempts which are being made in this country and abroad to develop engines of the Diesel type which will occupy the same fields as those in which the carburetor engine has been practically supreme for almost a generation. Recent announcements that an airplane with a Diesel-engine power plant has actually flown have increased speculation as to the effect which this new type of engine may have on the rapidly advancing art of aviation.

Readers of Mechanical Engineering have already had an opportunity to study the paper, published in the August issue and presented at State College, in which C. H. Gibbons writes on "Commercial Applications of High-Speed Oil Engines." The list of these applications is illuminating and impressive. It proves that the advantageous characteristics of the Diesel engine have stimulated a distinct demand for a light high-speed engine of this type. The problems involved are far from being solved, however, as both the papers and the discussions of Monday's session clearly indicated. In fact, Otto Nonnenbruck of I. P. Morris & De La Vergne, Inc., in his paper on "High-Speed Oil-Engine Design," expressed the opinion that high speed was being overdone. Discussion of the paper by J. L. Goldthwaite on "High-Speed Oil-Engine Pumps and Injection Valves" gave further proof of problems to be solved. Final emphasis was placed on this phase of the general situation by Wm. F. Joachim in his theoretical and fundamental paper on "Combustion in High-Speed Oil Engines." Mr. Joachim forcefully pointed out that the published theoretical and experimental work on oil engines is still far behind that on steam engines and turbines. He reviewed the work which has been done in this field, discussing the factors affecting combustion, and expressed the view that high speed could be accomplished only through an extensive study of the characteristics of the oil particle. This oil particle he likened effectively to a comet.

Two other features of the meeting stand out as being of especial interest. On Wednesday morning the session was devoted to costs, and in addition to the report of the committee on costs, a paper on "Maintenance and Repair of Marine Diesel Engines" was presented by Louis R. Ford, consulting engineer, of New York. The paper, which gave experiences in this field and indicated some of the difficulties involved, was published in Mechanical Engineering for August.

The report of the committee on costs, presented by Franz Eder, engineer, Robert W. Hunt Co., New York, N. Y., contained data from 27 plants with units ranging from 75 to 2250 hp. and representing a total output in 1927–28 of 75,395,250 kw-hr. Median values in mills per kilowatt-hour showed costs as follows: fuel oil, 4.2; lubricating oil, 0.43; attendance, 2.82; supplies, 0.63; repairs, 0.66; making the total cost 8.74 mills per kilowatt-hour. Individual figures varied widely.

The progress report of the special research committee on Diesel fuel-oil specifications was presented by Wiley H. Butler, Diesel engineer, Standard Oil Company of New Jersey, New York, N. Y. The committee was formed as a result of last year's meeting of the division at State College where the desirability of standard specifications for Diesel fuel oil was discussed. The specifications suggested in the report are for fuels for heavy-duty and light high-speed oil engines. The committee which drew the specifications represents in its membership the oil refiners, the manufacturers of oil engines, and the operators; three groups whose interests are at stake in the question involved. The refineries are prepared to supply samples of oil made in accordance with the proposed specifications to manufacturers who wish to determine if it can be successfully burned in their engines. In order that the committee may have the benefit of the results of the experimental work on a basis proper for comparison, a uniform test code has been prepared by the committee. It is gratifying to know that some engine manufacturers are already making tests of the fuel. Should a favorable decision be reached in regard to the specifications and a demand for the fuel develop, refineries will be able to supply it in commercial quantities. This will be a satisfactory culmination of the committee's activities, because the new fuel can be produced at a lower price than that now used, and the advantages of standardization will accrue to users, manufacturers, and refiners alike.

Teaching of Mechanical Engineering

A Brief Account of the S.P.E.E. Summer School for Teachers of Mechanical Engineering Held at Purdue University

THE stimulating experiences to which 89 deans, professors, and instructors of mechanical engineering were subjected at the S.P.E.E. Summer School for Engineering Teachers held at Purdue University from June 27 to July 18 are bound to have permanent and beneficial effects upon them and their profession. For three weeks the members of the summer school lived and ate under the same roof and sat together in the classroom listening to lecturers and taking part in discussions on the aims, content, and methods of teaching the subjects which comprise the mechanical-engineering curriculum. They represented 60 educational institutions and came from 36 states and two of the Canadian provinces. As a cross-section of the profession of engineering teaching they made as typical a group as could have been brought together. The open-minded, earnest, and intelligent attention which they gave to making the most of an exceptional opportunity leads to the conviction that the return on any investment which they, their institutions, or the sponsors and staff of the school may have made will be a handsome one.

The Summer School at Purdue is the third which has been conducted by the Board of Investigation and Coordination of the Society for the Promotion of Engineering Education. These schools may justly be considered an outgrowth of the searchingly introspective investigation which the Society is completing after five years of strenuous effort under the direction of Dr. W. E. Wickenden, president-elect of the Case School of Applied Science, and Prof. H. P. Hammond, Brooklyn Polytechnic Institute, associate director of investigation. The spirit of cooperation and the desire to improve their schools, their product, and their educational technique which characterized this undertaking afforded an opportunity to organize the summer schools for engineering teachers as a continuing enterprise growing out of the investigation. The school has now stood the test of three years.

In 1927 the school was conducted in two sessions, one at Cornell University, and the other at the University of Wisconsin, and was devoted to the study of the teaching of engineering mechanics. In 1928 a session on the teaching of electrical engineering was conducted at the University of Pittsburgh with the cooperation of the Westinghouse Electric and Manufacturing Company and one on the teaching of physics was held at the Massachusetts Institute of Technology. This year the school was under the joint sponsorship of the S.P.E.E., Purdue University, the A.S.M.E., and the Western Electric Company. Outside of three days of activity at Chicago where all of those registered in the school were the guests of the Western Electric Company, all of the sessions of the school were held at Purdue University.

Methods of Conducting the School

Lectures and discussions made up the day's work at Purdue. A staff of lecturers, qualified by their exceptional attainments as educators and engineers, had been recruited from engineering colleges and the industries. The program was so rich in valuable material carefully planned to fit into a preconceived scheme that every morning and afternoon, and many evenings, were devoted to lectures, discussions, and committee meetings.

Because mechanical engineering is a broad and inclusive field, it was decided to divide a portion of the program into three parts so that special emphasis could be placed upon three major branches of engineering subjects; heat power, machine design, and production. This plan provided smaller groups for the discussion of some of the more specific problems in these fields by men especially interested in teaching these subjects. The more general lectures and discussions were attended by all. The only disadvantage to the plan was that some very excellent lectures were given simultaneously, to the distress of those who wished to hear two or more speakers at the same hour. To have adopted a plan whereby every one might have heard every lecture, however, would have extended the length of the course unwisely.

The Program

It is impracticable in this short review to publish the entire program of the summer school. It will be found in the bulletins of the S.P.E.E. by those who are interested to know it in detail. In general, however, it was conceived on broad lines as witnessed by the fact that in addition to the more technical aspects of instruction, a considerable portion of the program was devoted to economic, social, and historical phases of engineering. It was as complete as could reasonably be expected in view of the time available, and showed careful planning.

One group of lectures was devoted to the content of courses, still another to methods which have been found successful in teaching, and a more general group constituted generally informative and timely reviews of present-day developments. The lecturers were chosen from among the teachers and practitioners of mechanical engineering and spoke with authority.

Some Impressions

The impressions which are made by such an experience as this one at Purdue will vary with the individual and are not always easy to transmit. The present reviewer, therefore, records some of his own interpretations of the more general themes which dominated, in his mind, the spirit of the papers and discussions.

There was, first of all, a reassuring conviction that teachers of engineering are on the right track. In an age of sudden changes and in a new environment, both attributable in a large degree to the impress of the engineer upon civilization, methods and purposes of education have undergone change also. While some have failed to recognize this fact, while others have been stampeded into ill-advised programs of specialty training, engineering teachers have been able to maintain a conservative balance with a progressive vision. What is more significant, they have, and in this they are unique, boldly questioned their aims, ideals, and methods, with a hope, which has been realized in part at least, of improving themselves, their schools, and their product. No other group of teachers, it may be confidently said, has done this in as thorough a manner, and no other group of teachers has formulated so definitely its ideas in these essential points. Colleges of liberal arts, offering varied programs of studies, have never given such strict attention to the result they hope to accomplish or the means by which it is to be accomplished because their objectives lack the definiteness which gives form to the engineering curriculum and the educational needs of the graduate engineer.

The common opinion expressed by professional educators, psychologists, practicing engineers, and industrialists that a broad training in fundamentals is of more value than attempts at specificity (a choice word which almost every one at Purdue understood even if he could not pronounce it successfully) was a

heartening indication that a grave danger that once beset engineering education has been passed.

So much has been said about the value of good English that the subject has become a trite one. The topic is so common in engineering discussions that it would be thought that some one would have done something about it. Protestations are beginning to have a hollow sound, progressing as they do such a little way into the realm of constructive suggestion. Two questions rather pertly suggest themselves: Are we talking about good English or correct grammar? Do we recognize good English when we read it? Engineers sin no more than any other group of non-professional writers when it comes to expressing themselves in print. Illiterate and non-grammatical writing should be corrected before a man enters college. To give a man an instinctive taste for good English cannot be accomplished as a by-product of reporting laboratory tests. What is needed is an inspiring teacher whose knowledge of science, engineering, the culture of all civilizations, and the literature of the world is augmented by a spontaneous and sincere enthusiasm for those broadening influences in human life. More literature and less composition is in line with generalization vs. specificity. The instance, cited by Dean Kimball, of readings in literature at Cornell, is a hopeful sign.

That engineering education must broaden at the top was the burden of much that Dean Kimball and others contributed to the conference. For many years it has been recognized that the purely technical subjects dealing with the physical sciences must be augmented by some of the economic and social sciences. As determined by the investigations of the S.P.E.E., at least two-thirds of the engineers who graduate from engineering schools eventually occupy administrative positions. The evidence is becoming clearer every day that leaders of industry must be trained in engineering fundamentals as well as those of finance and economics, and that it will be the function of the engineering school to educate the men who control the commercial phases of engineering and manufacturing projects. As civilization becomes more and more mechanized, so will this become more and more of an industrial era and its leaders will feel the need of an engineering and financial education. Most schools have made provision in their curricula for economics. Many have introduced courses in industrial management, in costs, and a few in finance in recognition of the value of these subjects.

All of these additions to an already crowded curriculum demand either the displacement of other instructional material or the extension of the length of the course to five or more years. A deep-seated prejudice to five-year courses exists. The demands of life upon education, however, may force the issue. The five years, however, will not be extended to include more technical subjects, but to include more liberal ones. Dean Kimball convincingly pointed out the need for a broader intellectual background for an engineer's attack on his highly important job. History, he pointed out, had never received the attention which a true evaluation of its importance would give it in an engineering curriculum. This is a concrete example of what we may expect educators to advocate more frequently in the future, when the natural reticence of engineers to admit the value of cultural studies has been overcome by such leadership as Dean Kimball displayed at Cornell. Men of affairs, while they may not always be conscious of the reasons for the shortcomings which they attribute to many engineers, have generally acquired, in one way or another, a knowledge of men and life. Not every man who studies engineering is inherently capable of industrial leadership. Qualities other than a facility in physical sciences are necessary and these some men do not possess naturally nor have they any hope of acquiring them. For the well-being of engineering, of education, and of industry and society, therefore, the best minds and the most capable men should be educated in engineering colleges. Tomorrow's aristocracy, using the term in its literal sense, will be made up of the men whose training in the culture of the sciences provides them with a mastery of their physical and social environment. To that philosophical understanding which comes with a sympathetic interpretation of the classics and cultures of the past they will add the creative and progressive spirit of the engineer whose eyes are forever pointed toward the future. But their education must be in the hands of men with superior intellects and ideals. The experience at the summer school indicates that teachers of engineering are alive to this important responsibility.

What Did the School Accomplish?

To evaluate adequately the benefits attributable to the summer school at Purdue is to attempt to give substance to a host of intangibles. Like the process of education, the experience will weigh differently with different men. It was a golden opportunity for the young instructor to adsorb in countless ways a realization of the significance and importance of his profession and to benefit by numerous very definite additions to his knowledge of the subject matter he is teaching. He went away with an improved technique derived from specific suggestions made by the lecturers and by his observations of them and their methods. He saw the subjects he had been teaching presented in a new light. He heard problems discussed, the significance of which had never before appealed to him, and an enthusiasm to tackle them himself fired his ambitions. He met and talked with men whom he had read about, whose books he had studied, whose names had been heroic to him.

The narrowness of sectionalism was dissipated in this meeting of men from all over the United States. The problems of teaching are largely similar, although local conditions may give them a different cast. And the local problems that arise in different social groups and sometimes affect major policies are more sympathetically understood after living three weeks with men representing so many of these groups.

The schools to which these men return will benefit in more ways than one. The man comes back a better teacher, a broader individual. His outlook upon the problems of his school is more mature and less provincial. Fortunate indeed is engineering education in general which can number among its teachers so many who have benefited from the experience of the summer school, and fortunate the college whose faculty contains several men so trained. An institution honestly trying to improve its methods and product will find that the slight expense involved in sending its instructors to one of these schools will be wonderfully fruitful. And yet, in spite of the obvious advantages to the school, more than half of the men who attended received no financial assistance from their institutions.

The engineering societies are also beneficiaries in this program. To them falls the responsibility of fostering and giving direction to the efforts of engineers to help their profession. The profession is changing. Older men retire, or die, but younger men take their places in greater numbers. Most of these men come from the colleges. It is to the advantage of engineering societies, as it is to society at large, that these young men be of the highest type and have the best training that can be given. Their outlook upon life must be broad and sympathetic. They have it in their power to advance or to retard the progress of the industrial age—to brighten its luster or to bring it into discredit. Jealous of the record its members have made, the engineering societies have a very definite stake in the progress of engineering education. They could wish that all engineering teachers might be men to inspire the best and noblest ambitions and the broadest outlook upon life in the young men whom they teach.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Books Received in the Library

AIRPLANE STRESS ANALYSIS. By Alexander Klemin. Ronald Press Co., New York, 1929. Cloth, 6 × 9 in., 277 pp., diagrams, tables, $7.

Professor Klemin's textbook is intended for college students who wish an accurate and complete yet simple treatment of the subject. After a review of the principles of applied mechanics, the subject is presented by a step-by-step analysis of the stresses in a hypothetical airplane. The necessary information about airplane materials is also included. The book covers the stress requirements of the Department of Commerce.

AIRPLANE STRUCTURES. By Alfred S. Niles and Joseph S. Newell. John Wiley & Sons, New York, 1929. Cloth, 6 × 9 in., 413 pp., diagrams, tables, $5.

A textbook of structural engineering, with special reference to the requirements of the designer of airplanes. The principles of structural theory are presented and their application to airplane design are described. Data on the allowable stresses in various materials and the allowable loads on standardized airplane parts are included to satisfy the ordinary requirements of the engineer. The book aims to combine an exposition of structural theory with sufficient practical information to solve the more common problems of the aeronautical structural engineer.

ARC WELDING; Lincoln Prize Papers submitted to The American Society of Mechanical Engineers. Edited by Edward P. Hulse. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 421 pp., illus., diagrams, tables, $5.

The Lincoln Arc Welding Prizes were given by the Lincoln Electric Company to be awarded by The American Society of Mechanical Engineers for the three best papers on arc welding. The seven papers published in this book include the three prize winners, the two that received honorable mention, and two others of unusual merit.

The papers are "Arc-Welding—Its Fundamentals and Economics," by James W. Owens; "Fundamental Principles of Arc Welding," by Prof. H. Dustin; "Electric Welding of Ships' Bulkheads and Similar Plated Structures," by Commander H. E. Rossell; "Theory and Application of the Base Plate Arc-Welded Rail Joint," by Frank B. Walker; "Stable Arc Welding on Long-Distance Pipe Lines," by B. K. Smith; "Arc Welding as Applied to Construction Work at the Philadelphia Navy Yard," by M. W. Kennedy and F. H. Wieland; and "Arc Welding of Duplicate Steel Structures," by W. H. Himes.

BASES OF MODERN SCIENCE. By J. W. N. Sullivan. Doubleday, Doran & Co., Garden City, N. Y., 1929. Cloth, 5 × 8 in., 274 pp., $2.

An admirable history of the growth and development of physical science from the time of Copernicus to the present day. Mathematical formulas are conspicuously absent, the treatment is as simple as the subject permits, and the book traces very satisfactorily the rise and decline of the conceptions which have dominated physics from time to time.

BEITRAG ZUR KLARUNG DER FRAGE, WIE DIE ASCHE NACH MENGE UND ART IM KOHLENSTAUB ENTHALTEN IST, UND WELCHE WEGE GEGEBEN SIND, SIE TROCKENMECHANISCH ZU BESEITIGEN. By H. Schwartzkopff. (Fünfzehnte Berichtfolge des Kohlenstaubausschusses des Reichskohlenrates.) V.D.I. Verlag, Berlin, 1929. Paper, 9 × 12 in., 24 pp., illus., diagrams, tables, 2.50 r.m.

The report of an investigation of the practicability of removing the ash from powdered coal by dry methods. The distribution of ash in powdered coal of various degrees of fineness was determined, as well as its character. Electrostatic, electromagnetic, and pneumatic methods of separation were examined. The conclusion was reached that dry methods of removing ash are not very efficient at present and would not be economical.

BERICHTE ÜBER BETRIEBSWISSENSCHAFTLICHE ARBEITEN, Vols. 1 and 2. V.D.I. Verlag, Berlin, 1929. Paper, 9 × 12 in., 63 pp. & 51 pp., illus., diagrams, 11 r.m. each.

The first two issues of a new serial devoted to the publication of complete reports of interesting investigations of processes and machinery which, for lack of space, cannot be given fully in ordinary periodicals. Each of these issues contains three reports from the laboratory of the Dresden Technical Institute. The first, on woodworking machinery, treats of planing, mortising, and working veneers. The second, on metal-working processes, discusses the drawing of hollow vessels from thin sheets, the efficiency of machine hacksaws, and broaching.

BERICHTFOLGE DES KOHLENSTAUBAUSSCHUSSES DES REICHSKOHLENRATES, 18th and 19th, April and June, 1929. V.D.I. Verlag, Berlin, 1929. Paper, 8 × 12 in., 16 pp. & 12 pp., 1 r.m. each.

The papers in these two reports of the Committee on Pulverized Coal discusses various questions of interest to users: facts for buyers; ignition and combustion phenomena at various furnace pressures; heat flow and storage in furnace walls; the behavior of ash; the possibility of separating ash from flue gases; conveying pulverized coal; and the extinguishing of pulverized-coal fires.

BORN THAT WAY. By Johnson O'Connor. Williams & Wilkins Co., Baltimore, 1928. (Human relations series.) Cloth, 5 × 8 in. 323 pp., illus., tables, $6.

This book describes a number of tests for selecting workers for various jobs, with directions for using and interpreting them and a discussion of their philosophy. For several years the author has been experimenting with these tests in the General Electric Co., during which time they have been applied practically to many workers in many localities, and have proved reasonably

accurate in predicting the line of work in which an individual may expect to succeed. A wide range of occupations is covered.

BUILDING ESTIMATORS' DATA BOOK. By Charles F. Dingman. McGraw-Hill Book Co., New York, 1929. Fabrikoid, 4 × 7 in., 159 pp., illus., tables, $2.50.

Tables are given for all the ordinary operations of building, with directions for their use. A careful selection of mathematical tables, formulas, and constants is also included. The data are arranged for ready use with calculating machines and show in most cases the number of labor hours required for a given quantity of construction.

BUSINESS LAW FOR ENGINEERS. By C. Frank Allen. Third edition. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., various paging, $4.

This text aims "to give the engineer a sufficient understanding of important fundamental features of law, so that he may have some idea of when or how to act himself and when to seek expert advice." The author has had experience both as an attorney and as a civil engineer. In this edition there is a new chapter on "cost plus" contracts, and several new forms of contracts.

COMPUTING COTTON FABRIC COSTS. By F. H. Hill, Jr. Published for the *Textile World* by McGraw-Hill Book Co., 1929. Cloth, 6 × 9 in., 122 pp., forms, $5.

A simple, practical discussion of the organization and operation of a cost-accounting system in a textile mill. In the first section methods are given for ascertaining the cost in each department, locating high costs, and checking waste. The second section shows how to ascertain the cost of fabrics.

DIAGRAMME UND TABELLEN ZUR BERECHNUNG DER ABSORPTIONS-KÄLTEMASCHINEN. By Fr. Merkel and Fr. Bosnjakovic. Julius Springer, Berlin, 1929. Paper, 8 × 11 in., 43 pp., diagrams, tables, 12 r.m.

The simple formulas and graphical tables, which the authors have prepared from recent investigations, simplify greatly the design of absorption refrigerating machines. The necessary data and tables are given here, with a description of their use.

DIE DAUERFESTIGKEIT DER WERKSTOFFE UND DER KONSTRUKTIONS-ELEMENTE. By Otto Graf. Julius Springer, Berlin, 1929. Paper, 7 × 10 in., 131 pp., illus., diagrams, tables, 14 r.m.

A review of our knowledge of the permanent strength of materials when subjected to repeated and long-continued stresses. Brings together in convenient form the available results of tests by the author and other engineers. The materials discussed include steel, cast iron, cast steel, copper, nickel, aluminum, magnesium and their alloys, stone, reinforced concrete, wood, and glass.

ELECTRIFICATION OF STEAM RAILROADS. By Kent Tenney Healy. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 395 pp., illus., diagrams, tables, $5.

Combines a description of the physical characteristics of the elements of electrification with an analysis of economic problems and the operating performance of both electrification and electric operation. Power contracts, overhead systems of distribution, and the economics of electrification are given special attention.

ENGLISH AND SCIENCE. By Philip B. McDonald. D. Van Nostrand Co., New York, 1929. Cloth, 6 × 9 in., 192 pp., $2.

Proper forms for formal and informal reports and for letters, the importance of correct language, common faults of poor writers, punctuation, and sentence structure are the subjects to which Professor McDonald devotes the greater part of his textbook. In addition there is much sound advice on minor matters and interesting suggestions for cultural reading. The book should be helpful in assisting professional men to attain a concise, attractive, clear style.

DIE FESTIGKEIT DER SCHRAUBENVERBINDUNG IN ABHÄNGIGKEIT VON DER GEWINDETOLERANZ, IM AUFTRAGE VON BAUER U. SCHAURTE. Edited by Kurt Mütze. Julius Springer, Berlin, 1929. Cloth, 6 × 9 in., 108 pp., illus., plates, diagrams, tables, 6.50 r.m.

This investigation of the factors that influence the strength of bolts was carried out at the Dresden Technical Institute, at the request of leading German bolt makers. The methods and instruments are described in full, as well as the results obtained.

FUNDAMENTALS OF FLUID DYNAMICS FOR AIRCRAFT DESIGNERS. By Max M. Munk. Ronald Press Co., New York, 1929. Cloth, 6 × 9 in., 198 pp., diagrams, $8.

During twelve years of work on aerodynamics, Dr. Munk tested many theories and developed a number of mathematical formulas to explain phenomena observed in research and flight tests. His results were published from time to time by the Inspection der Fliegertruppen and the U. S. National Advisory Committee for Aeronautics.

In the present book he presents the most useful portions of his earlier publications, systematized and revised in the light of his final conclusions. The formulas required by designers are given and their use is explained.

GENAUIGKEITSERMITTLUNGEN AN WERKSTÜCKEN ZUR BESTIMMUNG ZWECKMÄSSIGER PASSUNGSSITZE. By K. Gramenz. V.D.I. Verlag, Berlin, 1929. Paper, 9 × 12 in., 24 pp., illus., diagrams, 3 r.m.

The effectiveness and adaptability to shop practice of the system of fits and tolerances adopted by a factory is the subject under investigation here. The pamphlet describes methods and apparatus for determining the quality of workmanship existing in a factory, and for ascertaining the most economical degree of exactitude to be sought.

DIE GRUNDLAGEN DER TRAGFLÜGEL- UND LUFTSCHRAUBENTHEORIE. By H. Glauert. Translated by H. Holl. Julius Springer, Berlin, 1929. Paper, 6 × 9 in., 202 pp., diagrams, tables, 12.75 r.m.

A translation of "The Elements of Aerofoil and Airscrew Theory," with practically no changes from the English edition of 1926. The book presents the theory in a form suitable for students who do not know hydrodynamics, and avoids complex mathematical analysis.

HANDBOOK OF CORPORATE MANAGEMENT AND PROCEDURE. By Earl A. Saliers. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 1237 pp., forms, $7.50.

Discusses the more common problems that arise in the every-day affairs of corporations, such as the conduct of meetings of stockholders and directors, the handling of stock issues, the payment of dividends, the financing of working capital, the issuance of bonds, the transfer of capital stock, and the operation of voting trusts. The book presents data constantly wanted by those in charge of the legal, financial, and managerial activities of corporations.

DIE KUNST DER OFENPLATTEN; dargestellt an der Sammlung des Vereins deutscher Eisenhüttenleute in Düsseldorf. By Albrecht Kippenberger. Verlag Stahleisen, Düsseldorf, 1928. Cloth, 9 × 11 in., 52 pp., text, illus., 70 plates, 22.50 r.m.

The discovery, in the fifteenth century, of the art of casting iron was followed by practical use of the process for the production of many useful articles in artistic forms. The earliest product of this character was the stove plate.

This volume traces the technical and historical development of the art in various countries, gives what is known of the early designers, and discusses the relation of the stove plate to the general art of the renaissance. It is handsomely illustrated by photographs of the most noteworthy examples in the extensive collection exhibited in the Dresden Municipal Art Museum. The book will be of especial interest to iron founders and students of art.

Luftfahrtforschung, Vol. 3, No. 1–4; Feb.-April, 1929. R. Oldenbourg, Munich and Berlin, 1929. Paper, 8 × 12 in., 4 pts., illus., diagrams, tables, Part 1, 7.20 mk.; Part 2, 3.80 mk.; Part 3, 6.60 mk.; Part 4, 5 mk.

"Luftfahrtforschung" is an irregular serial devoted to the reports of the researches carried out in the aeronautical and aerodynamic laboratories at Berlin, Göttingen, Aix-la-Chapelle and other German cities. Twelve reports are included in the present four numbers, dealing with a variety of aerodynamic and structural problems. Number four is devoted to radio-communication from and to aircraft.

Manual of Engineering Drawing. By Thomas E. French. 4th edition. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 466 pp., illus., diagrams, tables, $3.

The fourth edition of this popular text has been made to conform to the standards of the American Standards Association, and certain topics, including auxiliary projections, dimensioning, and gears, have been expanded. The number of problems has also been increased. The book aims to provide a thorough course, based on good engineering practice.

Mechanics for Engineers. By Leroy W. Clark. Williams & Wilkins, Baltimore, 1928. Cloth, 6 × 9 in., 192 pp., diagrams, $3.50.

Simplicity and brevity are emphasized in this textbook based on the author's courses at the Rensselaer Polytechnic Institute. The book aims to give a knowledge of mechanics adequate for the needs of undergraduate students in a very short amount of time, and to provide the necessary foundation for advanced work by graduate students.

Men, Money, and Motors. By Theodore F. MacManus and Norman Beasley. Harper & Brothers, New York, 1929. Cloth, 6 × 9 in., 284 pp., $3.

This is the personal story of the pioneers of the automobile industry. Their early struggles, their failures and successes, are told graphically. It tells how the industry began, how the various companies grew and were consolidated into the present corporations, and of the personal fortunes of the leaders in developing them. An interesting story is told dramatically.

Pastures of Wonder; the Realm of Mathematics and the Realm of Science. By Cassius Jackson Keyser. Columbia University Press, New York, 1929. Bound, 6 × 8 in., 208 pp., $2.75.

Professor Keyser's book has a twofold purpose. He first endeavors to help the intelligent layman to acquire an understanding of the modern meaning of the term "mathematics." In the second part of his book, which discusses the meaning of the term "science," he proposes a definition of science which will, he believes, remove the ambiguity now associated with the word.

Pitman's Technical Dictionary of Engineering and Industrial Science in Seven Languages; English, French, Spanish, Italian, Portuguese, Russian, and German, vol. 1. Compiled by Ernest Slater. Isaac Pitman & Sons, New York, 1928. [3 vols. completed.] Cloth, 7 × 10 in., vol. 1, 582 pp., $12.50 a vol.

This dictionary will be found invaluable by every translator of English catalogs and technical articles and books into the languages that it covers. Unusual care seems to have been taken to cover the field adequately and to provide accurate equivalents. Special attention has been given to idiomatic phrases, and a useful essay on the art of technical translation is included.

Problèmes de Statique Graphique et de Résistance des Matériaux. By Louis Roy. Gauthier-Villars et Cie., Paris, 1929. Paper, 6 × 9 in., 119 pp., diagrams, 30 fr.

A collection of problems derived from examinations at the Institute of Electrical Engineering and Applied Mechanics at Toulouse University and those for certificates in applied mechanics. Intended as a companion to the author's textbook on the same subjects, and similarly arranged.

Railway Electrification and Traffic Problems. By Philip Burtt. Isaac Pitman & Sons, New York, 1929. Cloth, 6 × 9 in., 197 pp., illus., maps, $3.

A presentation of the general question of electrification from the point of view of a traffic manager. It brings together the pertinent facts from the experience of various countries and discusses the problems involved. The author is an advocate of electrification for main lines.

Rechnungswesen und Technischer Betrieb. By W. Lorch and Fr. Sommer. V.D.I. Verlag, Berlin, 1929. Linen, 6 × 8 in., 183 pp., forms, graphs, 12 r.m.

A textbook of accounting for industrial organizations, by two experienced managers. Special attention is given to cost accounting.

Six-Place Tables....with Explanatory Notes by Edward S. Allen. Third edition. McGraw-Hill Book Co., New York, 1929. Fabrikoid, 4× 7 in., 167 pp., $1.50.

These tables are clearly printed and the size is actually convenient for the pocket. The book contains the mathematical tables used regularly and continuously by engineers and engineering students, accurate to six places.

In the new edition the values of natural secants and cosecants have been added, and new tables for conversion between radians and degrees are included.

Treatise on Differential Equations. By A. R. Forsyth. Sixth edition. Macmillan Co., New York and London, 1929. Cloth, 6 × 9 in., 583 pp., $6.75.

Professor Forsyth's well-known volume is intended as a practical working textbook on the subject, and the general theory has been definitely avoided. The sixth edition varies from the fourth in minor matters only.

Wood Construction, Principles, Practice, Details; a project of the National Committee on Wood Utilization. Edited by Dudley F. Holtman. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 711 pp., illus., tables, $6.

This handbook is intended for architects, engineers, and builders. Its purpose is to give complete practical information on the use of wood in construction, to assist in the design and specification of wooden structures, and to point out efficient ways of selecting and using woods, and economical forms of design.

The factors that affect the use of wood, lumber grading, working stresses, the principal structural woods and their identification, preservative treatment, painting, and protection from termites are discussed at length. Approved methods of using lumber in light buildings, millwork, heavy timber structures, and temporary structures are also given. The book is sponsored by a committee representing national organizations of engineers, architects, and builders.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following pages appear in the current issues of Hydraulics, Machine Shop Practice, Materials Handling, Railroad and Wood Industries sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced when completed, in later issues of "Mechanical Engineering."

HYDRAULIC PAPERS

Progress in Hydraulics. [Paper No. HYD-51-1]

This report of the A.S.M.E. Hydraulic Division chronicles the advances made in its field during 1928. It calls attention to the economic features involved in new projects, and the recent revamping or complete reconstruction of old plants. Tests and research work on dams are noted, and the important new hydraulic-power developments are enumerated. Improvements in turbines and accessories are referred to, and features of operation such as remote control, the use of outdoor stations, are briefly discussed.

Tests on Small Rotary Pumps. By F. Aschne and L. Mattheus. [Paper No. HYD-51-2]

Gear pumps and other small rotary pumps are used for pumping lubricating oil, cooling water, and other liquids to all kinds of machines and especially to machine tools and steam and internal-combustion engines. Published information on the behavior of these pumps under a variety of pressures, speeds, and oil viscosities is very scarce, even though forced lubrication by means of such pumps is the basis of modern engine construction. The Mechanical Laboratory of the Technical University of Breslau has attempted to remedy this lack of data by performance and efficiency tests on these pumps under various working conditions. These tests were made on rotary piston pumps as used on the Hispano-Suiza engine and gear pumps for machine tools and automobile engines. The results of the tests are given in the form of curves and tables, and afford useful data for the use of designers of such machinery.

New Aspects of Maximum Pressure Rise in Closed Conduits. By S. Logan Kerr. [Paper No. HYD-51-3]

This paper discusses the various elements entering into the determination of the true maximum rise in pressure which may occur in closed conduits. It shows that, contrary to the usual belief, the maximum rise in pressure will not necessarily be produced when the full flow in a given conduit is cut off, but is a function of the initial flow from which the deceleration starts. The necessity of establishing the relation between the average conduit velocity and the rate of gate travel for various proportional strokes is cited.

Comparison is made of the computations by several of the accepted methods based on the elastic wave theory, and a translation of important studies made by M. Maurice Gariel in France is included. The application to practical cases is outlined and specific examples are worked out in detail.

A general summary of water-hammer computations is given with several simple formulas for the rapid calculation of the critical conditions.

Dredge-Pump Pressures and Thrust Loads. By James H. Polhemus and James Healy. [Paper No. HYD-51-4]

The Port of Portland engineering staff, desiring to determine the actual thrust loads and pressures acting on the impeller of a dredge pump, carried on some tests which should be of interest to members of this society.

Pressure gages were installed at controlling points in both the front and back heads of the 2700-b.hp. 30-in. pump of the dredge Clackamas and a series of tests run to determine the effect of varying lengths of pipe line, impeller clearances, and impellers with and without relief holes in the back shroud.

The results of the tests showed clearly:

1 That relief holes in the back of the impeller materially reduced the thrust load and did not reduce the efficiency of the pump to any noticeable degree.

2 That renewable clearance rings and small vanes on the outside of the impeller shrouds are necessary to maintain close clearances and control the thrust loads.

3 While large clearances produce low thrusts, close clearances do not create a prohibitive thrust and are necessary to maintain a high pump efficiency.

4 That the pressures on the front and back shrouds are not the same and are considerably less than the pump discharge pressure.

5 That the whirlpool pressures are not as high as the discharge pressure of the pump, and that the pressures in the lower half of the pump casing are somewhat greater than those in the upper half.

6 That it is not necessary to carry the same pressure on the water service to the pump-shaft seal as is the discharge pressure of the dredge pump.

7 That as might be expected the thrust load increased with the total head.

8 That the thrust load is greater for any given condition when pumping material rather than water.

9 That the thrust loads are less for any given heads with the smaller high-speed pump impeller as compared with larger slow-speed impellers.

Thermodynamic Theory of the Air Lift. By Alexey J. Stepanoff. [Paper No. HYD-51-5]

The air lift as a method of pumping from deep wells is subject to no generally accepted theory that will serve as a basis for practical design. Treating the air-lift pump as hydraulic apparatus, the thermodynamic side of the phenomenon has been neglected, and this method will explain many points in the operation that now are obscure. In his conclusions the author decides that the efficiency of the air does not depend upon the form of the footpiece if the air-inlet devices do not obstruct the flow of water, if the openings for the air are sufficiently large to cause no impact, and if the air and water are so introduced as to secure uniform mixture. Attempts to introduce jet action of the air are due to misunderstanding the method of action. Slip losses are usually due to incomplete expansion of the air, the slip as such being not of much importance. No "single coefficient" experimental formula can express the variables involved in the air lift, as its operation depends upon factors which vary differently for various submergences, air-to-water ratios, sizes of pipes, etc.

Some Interesting European Hydraulic Turbine Research. By Blake R. Van Leer. [Paper No. HYD-51-6]

This paper deals with certain European turbine researches and results which have not hitherto been widely disseminated in America. The author discusses the extensive use of models in European laboratories and the subject of cavitation, and describes the Kaplan and Banki turbines, and sets forth at some length the theory of the latter.

MACHINE-SHOP PRACTICE PAPERS

Progress in Machine-Shop Practice. Contributed by the Machine-Shop Practice Division. [Paper No. MSP-51-1]

This report summarizes the progress made in machine-shop practice during the 18 months ending in December, 1928. It indicates the direction of progress as measured in terms of machine-tool development and improvement in processes under 30 specific headings, refers to the research projects under way, and enumerates the codes and standards affecting machine-shop practices which have been approved within the year and a half dealt with.

The Development of Automatic Measuring Devices and the Use of Optical Methods. By Earle Buckingham. [Paper No. MSP-51-2]

Measuring operations to insure a correct product are divided into three classes by the author. The first includes the preliminary measurements of the productive equipment; second, the inspection of the set-up of this equipment, which usually is accomplished by careful measurement of the first piece produced; and third, check

measurements required to insure that the set-up and tools retain their accuracy, as well as to sort out any faulty parts.

Automatic measuring instruments are divided into three classes. First are those used as a direct substitute for hand measuring instruments, such as dial indicators, optical comparators, and toolmakers' microscopes; second, special and standard measuring devices built into special fixtures and machines for the purpose of measuring a specific product; third, sizing devices built into the productive equipment to control the feed or operation of the machine.

HELICAL GEARS. By Thomas P. Colbert. [Paper No. MSP-51-3]

Designers seem to avoid helical and worm gears as being unsuitable and too expensive. A reliable method of selecting gears for a given purpose would result in more frequent applications. The author gives charts and formulas designed to make the computing of spiral gears less difficult.

DEVELOPMENT OF MEASURING DEVICES, PRIMARILY MANUAL. By James A. Hall. [Paper No. MSP-51-4]

In this paper the author gives a history of the development of measuring devices and describes some of the difficulties of fine measurement. Changes in length of steel scales with temperature make them correct only at one temperature. Every force is accompanied by a deformation of the material, and often very small forces may cause large errors when compared with the limits of measurement. Another difficulty is that gages and measuring devices which are correct today may be off a year from now due to changes in internal structure of the steel.

GROOVING BEARINGS IN MACHINES. By G. B. Karelitz. [Paper No. MSP-51-5]

Typical examples of grooving to assist in distribution of the lubricant to bearings are given in this paper, and the principles of lubrication are discussed. Proper cross-section of the grooves is considered as very important for satisfactory operation, and the author feels that a large number of machine-bearing troubles would be eliminated and wear would be decreased if more attention were given to the fundamentals of lubrication when machines are designed.

THE USE AND APPLICATION OF MACHINE TOOLS. By L. L. Roberts. [Paper No. MSP-51-6]

The author, who is mechanical superintendent of a large automobile manufacturing concern, briefly discusses the purchase, tooling, and equipment of new machinery, the shifting of machining jobs from one type of machine to another, the matter of replacements, production vs. floor space, motor drives, hopper feeds, and other details of motor-car production.

MECHANICAL APPLICATIONS OF CHROMIUM PLATING. By W. Blum. [Paper No. MSP-51-7]

After giving particulars regarding the physical properties of chromium such as hardness, thermal expansivity, density, melting point, electrical conductivity, and adherence, the author discusses the uses to which chromium plating, by reason of its wear-resisting qualities, has been more or less successfully put: namely, its application to gages and other measuring devices; to drawing, forming, stamping, and molding dies; to rolls for forming metals; to tools for cutting metal; to bearing surfaces in machinery, etc. He shows how in addition to savings due to the longer life of chromium-plated tools and parts, there are savings much greater in amount resulting from reducing the number of times that machines must be stopped for their replacement.

MATERIALS HANDLING PAPERS

PROGRESS IN MATERIALS HANDLING. Contributed by the Materials Handling Division. [Paper No. MH-51-1]

This report, after mention of the trend in construction, gives brief particulars regarding developments in specific types of equipment, including devices for bulk handling, conveyors, cranes, and hoists, electric and hand trucks, etc. Applications of materials-handling apparatus in a number of industries are cited, and the matter of research is discussed.

AERIAL ROPEWAY ERECTED IN CYPRUS FOR THE TRANSPORT OF ASBESTOS. By I. Bertolini. [Paper No. MH-51-2]

This ropeway, $18^1/_2$ miles long connects asbestos mines 4500 ft. above sea level with the nearest port, which is 37 miles distant by road. It is Diesel powered, has a down capacity of 12 tons per hour and 3 tons up. The ropeway has cut the cost of transporting asbestos to one-third of the former figure, and if the savings in transporting goods and supplies from the port to the mines are considered, the cost of handling the asbestos in the author's opinion, should finally be reduced to nil.

MATERIALS-HANDLING METHODS AT EASTERN STEEL CASTINGS COMPANY. By F. D. Campbell. [Paper No. MH-51-3]

The author describes a successful endeavor to completely mechanize a conventional type of jobbing foundry and transform it into a systematic manufacturing unit, and summarizes the results obtained.

HANDLING MARINE SHIPMENTS OF PULPWOOD. By Daniel W. Coe. [Paper No. MH-51-4]

The author describes a radical departure from common practice in loading vessels with pulpwood. The logs are first collected in a concentrating basin where they form several layers reaching a depth of about 4 ft. Self-propelled steam-operated hoisting towers with through-type booms remove this wood by means of "pulpwood trappers"—which are special devices of the same nature as grab buckets—and discharge it in the vessels' holds. Desirable advantages are claimed for the method.

BENDING STRESSES IN WIRE ROPE. By C. D. Meals. [Paper No. MH-51-5]

There is great variance of opinion among engineers and rope manufacturers as to the effect of bending stresses on the life of wire rope. The problem is not susceptible of absolutely accurate solution since it is impossible to eliminate certain variables which greatly influence it. However, certain studies and tests recently completed indicate that the bending-stress factors can be ascertained to a point where they are of practical value, and these the author briefly reviews.

THE MATERIALS-HANDLING PROBLEM IN THE PUBLIC UTILITY. By John C. Somers. [Paper No. MH-51-6]

This paper is a definite attempt to summarize the problem in general terms, with specific reference to the central-station industry. The author states that there are certain items which are significant in the solution of the handling problem of the utility: namely, (1) periodic check-up on overall conditions; (2) constant study and observation of trend and development; (3) selection and proper justification of equipment; (4) satisfactory installation of equipment; and (5) standardization of operating conditions. A consideration of these items, he states, will be of definite value to the utility engineer in dealing with his materials-handling problems.

RAILROAD PAPERS

PROGRESS IN RAILROAD MECHANICAL ENGINEERING. Contributed by the Railroad Division. [Paper No. RR-51-1]

This report deals with the growing competitive activities of automotive vehicles and aircraft, with the efforts of the railroads to speed up rail transportation and to employ more powerful locomotives, with the extension of the use of roller bearings on cars, improved springing, and numerous other details of development in the railway field during 1928.

SOLID CARBON DIOXIDE FOR RAILWAY REFRIGERATING CARS. By J. W. Martin, Jr. [Paper No. RR-51-2]

Solid carbon dioxide prepared by compressing rapidly evaporating liquid carbon dioxide into blocks of snow possesses an extraordinarily high latent heat. In this paper the author describes the refrigeration properties of solid carbon dioxide and its application to the solution of refrigeration problems.

Some of the most outstanding problems in connection with refrigerator cars are summarized and the particular advantages of solid carbon dioxide for this use are discussed.

CHARACTERISTICS OF INJECTORS. By R. M. Ostermann. [Paper No. RR-51-3]

Calculations of injector performance are given in this paper with particular reference to use on locomotives with exhaust-steam pressures. A group of curves are given to show the limits of stability of a No. 10 Elesco injector when handling certain quantities of water of various temperatures from the supply tank and when operated with varying exhaust-steam pressures against a boiler pressure of 190 lb. gage. The calculations and curves presented have more the

purpose of illustrating the relative behavior of different forms of injectors than of establishing definite operating records.

THE SCHMIDT HIGH-PRESSURE LOCOMOTIVE OF THE GERMAN STATE RAILWAY COMPANY. By R. P. Wagner. [Paper No. RR-51-4]

In this paper the author gives a description of the Schmidt high-pressure locomotive and presents the story of many years of elaborate development, which finally resulted in raising locomotive efficiency to 9.4 per cent. Among the difficulties that had to be overcome are mentioned the raising of boiler pressure, the discarding of the hundred-year-old Stephenson firebox, and the evolving of a new principle of indirect steam generation.

WOOD INDUSTRIES PAPERS

PROGRESS IN THE WOOD INDUSTRIES. Contributed by the Wood Industries Division. [Paper No. WDI-51-1]

In this review of developments in 1928 the committee notes among other things the steady increase in the use of dimension stock; the increased use of individual motor drive; the tendency to standardize on 60-cycle current, either 220 or 440 volts; the advent of more powerful machines and of multiple-operation units; increased use of fancy veneers and of lacquers; and the increasing use of power-driven hand tools. The research activities of the Society on saws and knives are referred to, as well as the Department of Commerce's work to promote economy and efficiency in woodworking.

MECHANICAL HANDLING OF LUMBER. By Carle M. Bigelow and Thomas D. Perry. [Paper No. WDI-51-2]

The authors describe and illustrate the more important methods of mechanical lumber handling used in wholesale and retail yards and planing mills, and of handling structural timbers and packaged lumber. As it costs $1 for each handling of 1000 ft. of lumber, and as experience shows that in practically every woodworking operation there are two unnecessary handlings, the authors point out that there is an economic waste of $76,000,000 annually in this country because of inefficient handling.

BALL BEARINGS AS APPLIED TO WOODWORKING MACHINERY. By H. E. Brunner. [Paper No. WDI-51-3]

Anti-friction bearings have come into general use in all classes of woodworking machinery. Their adoption has been largely influenced by the trend to higher operating speeds and increased production. Considerable study and effort have been expended in developing the details for application of ball and roller bearings to the various types of equipment. The principles underlying the practice which is now generally followed are brought out by descriptions of actual bearing installations. Special considerations entering into the design and manufacture of bearings for this field are discussed. The question of lubrication, important from the point of view of the machinery operator, is considered, and requirements of lubrication peculiar to anti-friction bearings are discussed in detail.

THE APPLICATION OF UNIVERSAL CHUCKS TO WOODWORKING MACHINERY. By A. E. Englund. [Paper No. WDI-51-4]

The author draws attention to the economies and improvements that can be secured by the use of universal chucks on woodworking machines, particularly boring and routing machines and lathes. He describes types of shanks and spindles which, used with universal chucks, will insure higher accuracy and greater rapidity in changing bits or drills than can be secured by any other means, and states that standardization in woodworking can certainly be approached by the use of straight-shank drills held in standard universal chucks.

LUBRICATION OF BALL-BEARING WOODWORKING SPINDLES. By Harry R. Reynolds. [Paper No. WDI-51-5]

The purpose of this paper is to bring out methods of lubrication especially suitable for speeds of 4000 to 7500 r.p.m. which is about the range of woodworking spindles.

The author sums up by stating that where oil is used its level should not be over the center of the lowest ball if speeds are higher than 500 r.p.m. At 5000 to 5700 r.p.m. a very light spindle oil should be used, and it should be fed either by wick or circulation from pump as any depth of oil around the balls will cause tremendous churning. Too much oil should not be used as it will cause heating, and the higher the speed the greater the heat.

If grease of the proper consistency is used, the housing can be filled. At high speed there will be a path cut through the grease by the balls, and if temperature develops, just enough melting will occur to furnish the lubrication required. Greases soft enough to churn should be avoided for high-speed applications as the heat generated will melt them so fast that conditions will duplicate those of too much oil. Failure is generally due to dirt, so the bearings must be kept clean. Especial care should be taken in renewing the lubricant, as this is when most of the dirt gets in.

REDUCING WASTE BY IMPROVEMENT OF DESIGN AND USE OF WOODWORKING SAWS AND KNIVES. Progress Report of the A.S.M.E. Special Research Committee on Saws and Knives. [Paper No. WI-51-6]

This first report of the Committee is an outline of the problem and specially emphasizes three points. These are:

1 Economic utilization of lumber, or the reduction of wastage in sawdust and shavings to a minimum point consistent with the cutting apart of the pieces of lumber and the machining to the desired shapes and sizes.

2 Conservation of power, or the reduction of the power factor in the operation of saws and knives to a minimum requirement.

3 The selection and classification of the most effective types, sizes, and shapes of tools to produce the foregoing results.

NOTE: Those who have not registered in the A.S.M.E. Hydraulics, Machine-Shop Practice, Materials Handling, Railroad and Wood Industries Divisions whose papers are abstracted on this and the previous pages, and who desire copies of any of these papers, may obtain them by using the form given below.

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AERODYNAMICS

Progress. Recent Progress in Aerodynamics, E. Ower. Discovery (Lond.), vol. 10, no. 114, June 1929, pp. 183–187, 3 figs. Chief form of apparatus used in aerodynamic research considered; National Physical Laboratory wind tunnel; results of recent aerodynamic research; description of slotted wing; slot is very effective means of delaying break away and of increasing maximum lift wing can develop; how resistance offered by airplane arises; resistance problems; wing flutter.

Theory. Modern Hydrodynamical Theory With Special Reference to Aeronautics, F. D. Murnaghan. Am. Mathematical Soc.—Bull., vol. 35, no. 3, May-June 1929, pp. 294–318, 3 figs. Particle and local differentiation; principle of conservation of mass; equations and concept of perfect fluid; Bernoulli's theorem connecting pressure and velocity; forces and turning moments experienced by solids in fluid; complex velocity and potential; flow around circular cylinder and airfoil; Blasius formulas for lift and turning moment; circular-arc and straight-line profile; Joukowsky profiles and their extensions; determination of airfoil of minimum induced drag having given lift; comparison with experiment. Bibliography.

AIR CONDITIONING

Equipment. Air Conditioning—Its Phenomenal Development, W. H. Carrier. Heat. and Vent., vol. 26, no. 6, June 1929, pp. 115–118, 6 figs. Evolution of humidifiers and other air-conditioning equipment; features of Carrier centrifugal-refrigeration units, air-conditioning installation in United States Capitol, unit air conditioners, etc.

Finishing Rooms. Controller Humidity in Finishing Rooms, E. B. Smethers. Indus. Finishing, vol. 5, no. 7, May 1929, pp. 40 and 42. Why humidity, or relative moisture content in air, is so important in connection with industrial finishing, some of troubles that are traceable to "unbalanced" air conditions, and how to control humidity.

AIRFOILS

Aerodynamic Characteristics. Aerodynamic Characteristics of Airfoils. Nat. Advisory Committee for Aeronautics—Report, no. 315, 1929, pp. 385–418, 104 figs. Collection of data on airfoils made from published reports of number of leading aerodynamic laboratories of United States and Europe; information presented in uniform series of charts and tables suitable for use of designing engineers and for purposes of general reference; absolute system of coefficients used; test data are presented in form of curves from which coefficients can be read with sufficient accuracy for designing purposes; shape of section is also shown with reasonable accuracy.

AIRPLANE ENGINES

Cowling. The New N.A.C.A. Cowling and Its Application to the Lockheed "Air Express," G. F. Vultee. Aero Digest, vol. 14, no. 3, Mar. 1929, pp. 43–44 and 222 and 224, 4 figs. Simple explanation of aerodynamic principles of new cowling; some difficulties already encountered in its application to record-breaking Lockheed Air Express; methods employed in overcoming these difficulties; any reduction in drag obtained by its use is due to its effect on fuselage aft of engine and cowling itself; form of fuselage over after portion is now more than ever of paramount importance.

Diesel. Diesel Air-Triumph Has Broad Significance. Oil Engine Power, vol. 7, no. 6, June 1929, pp. 332–334, 3 figs. Nine points of superiority of Diesel over gasoline engine for powering airplanes are discussed, covering ignition reliability, fuel-supply reliability, fire-hazard at vanishing point, fuel weight reduction, fuel cost reduction, manifolding eliminated, weather and humidity without effect, no radio interference, and fewer engines for large planes.

Fuel Requirements. The Problem of Engine Fuel Requirements, J. M. Shoemaker. Aviation, vol. 26, no. 26, June 29, 1929, pp. 2274–2277. Discussion of characteristics of aircraft fuels and important part they play in efficient and economic operation; large majority of purchasers of low-powered airplane engines will be content with low-compression engines, for which there is nation-wide distribution of moderate priced fuel which they can use with no danger of engine trouble; requirement that type test by run on relatively low-anti-knock fuel will place all engines on same basis; development in aviation gasoline used in Naval aircraft outlined.

Humidity Effect. Correcting Engine Tests for Humidity, D. S. Brooks. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 309, June 1929, 12 pp., 11 figs. Results of investigation made by Bureau of Standards of effects of humidity on engine performance; test made with different mixtures of gasoline in 6-cylinder three-port overhead-valve engine of $3^1/_8$-in. bore and $4^1/_2$-in. stroke coupled to Sprague electric dynamometer and spark accelerometer; work shows failure to allow for effect of differences in atmospheric humidity may introduce errors as great as would be occasioned by failure to allow for changes in barometric pressure; charts presented.

Superchargers. An Investigation of the Use of Discharge Valves and an Intake Control for Improving the Performance of N.A.C.A. Roots-Type Supercharger, O. W. Schey and E. E. Wilson. Nat. Advisory Committee for Aeronautics—Report no. 303, 1928, 9 pp., 5 figs. Practicability of using mechanically operated discharge valves in conjunction with manually operated intake control; valves of oscillating or rotating type; percentage power saving and actual horsepower saved determined for altitudes from 0 to 20,000 ft.; power saving of approximately 26 per cent at critical altitude of 20,000 ft.; valves reduce amplitude of discharge pulsations and increase volumetric efficiency.

AIRPLANES

Design. Analysis of the Wing and Other Indeterminate Structures, J. Fradiss and A. Thieblot. Aviation (Aeronautical Eng. Sec.), vol. 26, no. 24, June 15, 1929, pp. 86–90, 10 figs. Analysis of wing structure of conventional type made by two spars, compression members, and drag truss with fabric cover; focus of airfoil section and influence of moment coefficient in choice of airfoil section; elastic center of wing section; exact method for calculating load and method based on elastic center are described.

Notes on the Design of Ailerons, H. A. Sutton. Aviation (Aeronautrical Eng. Sec.), vol. 26, no. 24, June 15, 1929, pp. 91–93, 10 figs. Design of aileron controls is particularly susceptible to improvement in many airplanes; control system should be simple; proportions of ailerons to wing area in use on number of representative planes; representative types of aileron balance; Frise balance most satisfactory.

Manufacture. Mass Production Methods Used in Airplane Plant, B. Finney. Iron Age, vol. 124, no. 1, July 4, 1929, pp. 1–5, 10 figs. Mass production methods employed by Waco Aircraft Co., Troy, Ohio, for turning out six fuselages a day with capacity for ten; details of new plant; close attention to detail in rib construction; tubing stockroom adjoins machine shop; assembly line for fuselage; planes subjected to rigid tests.

Materials and Methods of Construction in Light Structures, A. Rohrbach. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 515, May 1929, pp. 22, and (discussion),

Note.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

pp. 22–46, 8 figs. Materials for airplanes and production problems discussed; questions of wood or metal, duralumin or steel, open or closed profiles, and of metal or fabric covering; metal covering practical only when wing is so made that inside is rendered accessible by simple unscrewing of portion of wing; how Rohrbach factory is endeavoring to reduce production costs. From yearbook of Wissenschaftliche Gesellschaft fuer Luftfahrt, Dec. 1926.

Progressive Assembly of Airplanes Resembles Automotive Production. Automotive Industries, vol. 60, no. 21, May 25, 1929, pp. 800–802, 6 figs. Description of control system used by Metal Aircraft Corp., Cincinnati, which illustrates possibilities of mass manufacturing methods for aeronautical industry; only 7 shapes and sizes of Alclad or dural are bought by company for manufacturing Flamingo monoplanes; all production operations except those of fuselage assembly are housed under one roof in progressive production system.

Stress Measurements. Force Measurements on Airplanes, F. Seewald. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 519, June 1929, 22 pp., 16 figs. Problem of separation of effect of engine and propeller and of airplane on performance of whole airplane; tests made by D.V.L. (German Institute for Aeronautic Research); two new hubs for measuring propeller thrust and engine torque; limitations of accelerometer for measuring forces in airplane; more accurate method in which deflections are scratched on plate; test of float and hull resistance. From Zeit. fuer Flugtechnik und Motorluftschiffahrt, Oct. 7, 1928.

Tail Surfaces. The Pressure Distribution Over the Horizontal and Vertical Tail Surfaces of the F6C-4 Pursuit Airplane in Violent Maneuvers, R. V. Rhode. Nat. Advisory Committee for Aeronautics—Report, no. 307, 1929, 20 pp., 29 figs. Investigation made at request of Navy Bureau of Aeronautics for determining maximum loads during violent maneuvers; existing loading specifications do not conform satisfactorily to loadings existent in critical conditions; in some cases exceeded; acceleration of 10.5 g. recorded in one maneuver in which pilot suffered severely; limits of physical resistance of pilot to violent maneuvers being approached; Navy specifications for structural design included.

AIRPLANE WINGS

Fuselage Effect. Investigation of the Effect of the Fuselage on the Wing of a Low-Wing Monoplane, H. Muttray. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 517, June 1929, 16 pp., 22 figs. Results of tests of mutual action of wing and fuselage, which greatly affects construction of airplanes, are dealt with; effect of distance between wing and nose of fuselage, measured along fuselage axis, on position of fuselage with respect to wing; transition from fuselage to wing root, which, if inadequate on low-wing monoplanes may become dangerous by causing air flow to separate at wing root; mutual interference for various wing shapes. From Luftfahrtforschung, June 11, 1928.

Slotted. Pressure Distribution on a Slotted R.A.F. 31 Airfoil in the Variable Density Wind Tunnel, E. N. Jacobs. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 308, June 1929, 13 pp., 12 figs. on supp. plates. Measurements made in variable-density wind tunnel to determine pressure distribution over one section of R.A.F.-31 airfoil with leading edge slot fully open, to provide data for study of scale effect; tests conducted with air densities of approximately 1 and 20 atmospheres; full-scale maximum lift somewhat lower than maximum lift indicated by low scale. Bibliography.

Spars. Single-Spar Monoplanes. Aeroplane (Lond.), vol. 36, no. 22, May 29, 1929 (Aeronautical Eng. Supp.) pp. 883–884, 6 figs. Use of single spar in modern cantilever deep-section monoplane wing with bracing to overcome torsional flexibility is discussed; description of patent specification is given for wing built up round single spar which takes all forces acting on wing including lift, drag, and torsion.

AIRPORTS

Floating. Seadrome Ports of Call Attaining Recognition, B. C. Smalley. Airports, vol. 2, no. 6, June 1929, pp. 35 and 48. Description of Armstrong seadrome which is to be anchored in ocean between New York and Bermuda; seadrome, comprising steel landing deck, hotel, hangars, shops, stores, administration and technical offices, and crew quarters, is supported through system of steel and iron streamlined columns terminating in buoyancy and ballast tanks, all with displacement of about 25,000 tons.

Lighting. Flying Field and Airway Lighting, H. R. Ogden. Am. Inst. Elec. Engrs.—Advance Paper, for mtg. May 7–9, 1929, 7 pp. Method of lighting airports and airways; various types of lamps and equipment used for purpose are described; information on airport illumination, including beacons, obstruction lights, boundary lights, illuminated wind direction indicators, field and building flood lights, signal lights, and ceiling illumination; portion on airway lighting covers principal and intermediate beacons and emergency field lighting. Bibliography.

Planning. Airport Design and Construction, R. L. Davison. Arch. Rec., vol. 6, no. 5, May 1929, pp. 490–515, 182 and 184, 30 figs. Description covering requirements for location of airport, design of structures for public, design of hangars and control tower; comparative costs of wood and steel hangars; airplane sizes; basic field design; types of field; runway construction; Department of Commerce requirements; comparative shapes and sizes of European airports are shown.

AIRSHIP ENGINES

Graf Zeppelin. The Engines of the "Graf Zeppelin," A. V. Bruemmer. Eng. Progress (Berlin), vol. 10, no. 3, Mar. 1929, pp. 57–59, 3 figs. Description of certain details of design resulting from particular requirements such as speed, fuel, starting device, supporting cradle, etc.

AIRSHIPS

Metal Construction. Stainless Steel Members in R-101, J. F. Hardecker. Iron Age, vol. 123, no. 26, June 27, 1929, pp. 1753–1758, 9 figs. Metal construction of R-101 employing stainless steel in main frame is discussed; intersections between main frame and longitudinal girders; closed and open tube used for booms of girders and struts; methods employed by Boulton and Paul for working stainless steel; main longitudinal and frame longitudinal consist of stainless-steel booms, tubular duralumin struts, and swaged rod cross-bracing.

R-101. On Seeing the Big Airship. Aeroplane (Lond.), vol. 36, no. 22, May 29, 1929, pp. 865–866, 868 and 872, 5 figs. Description of visit of Royal Aeronautical Society to Cardington to view Government-built airship R-101; details of cabins and main, smoking and dining rooms; heating of quarters; furniture.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.
Beryllium. See BERYLLIUM ALLOYS.
Bronze. See BRONZE.
Copper. See COPPER ALLOYS.
Nickel. See NICKEL ALLOYS.

ALUMINUM ALLOYS

Analysis. Aluminum and Its Formation of Mixed Crystals With Silicon (Aluminum und seine Mischkristallbildung mit Si), L. Anastasiadis. Zeit. fuer Anorganische und Allgemeine Chemie (Leipzig), vol. 179, no. 1/3, Feb. 19, 1929, pp. 145–154, 7 figs. Alloys of aluminum containing 0.53, 0.79, 1.01, 1.27, and 1.6 per cent silicon were heated for 50 to 74 hr. at 570 deg. and then quenched in water at 5 per cent; they were then subjected to thermal analysis; there is no polymorphic transformation in aluminum as is shown by electric resistance at room temperature for 99.94 per cent aluminum, no matter whether aluminum be quenched or cooled slowly from 630 deg.

Automotive. Aluminum for the Automotive Industry, Z. Jeffries. Soc. Automotive Engrs.—Jl., vol. 24, no. 6, June 1929, pp. 617–619 and (discussion) 619–620, 7 figs. Outline is given of strength that can be expected from various cast and wrought aluminum alloys, with heat-treatment necessary to develop best strength; for intercrystalline embrittlement, which causes trouble with thin sheets of aluminum alloy used around salt water, remedy offered is thin coating of practically pure aluminum, which is free from attack and protects stronger alloy both mechanically and dielectrically; magnesium-base alloys.

Corrosion. Micrographic Study of Corrosion of Certain Light Alloys in Seawater (Etude micrographique de la corrosion de quelques alliages legers par l'eau de mer), R. Cazaud. Revue de Métallurgie (Paris), vol. 26, no. 5, May 1929, pp. 274–281, 21 figs. Results of analysis of extra pure and commercial aluminum, aluminum-silicon alloys, aluminum-magnesium alloys, and duralumin.

Die Casting. Aluminum Alloys for Pressure Die Castings, S. Tour. Am. Soc. Testing Matls.—Preprint, no. 51, for mtg. June 24–28, 1929, 18 pp., 8 figs. Properties required in finished aluminum-alloy pressure die castings and properties required of aluminum-alloys to make them suitable for pressure die-casting process are enumerated and described; effect of various steps of process on properties are discussed as well as relation between alloy specifications and effect of impurities.

Oxyacetylene Welding. Oxwelding Aluminum and Its Alloys. Oxy-Acetylene Tips, vol. 7, no. 10, May 1929, pp. 193–200, 17 figs. Discussion of current practices in oxwelding commercial grades of aluminum; three general groups of alloys; advantages of oxwelded construction; welding sheet aluminum; use of jigs in welding aluminum; precautions to be observed; welding aluminum castings; welding strong aluminum alloys.

AUTOMOBILE ENGINES

Connecting Rods. Connecting Rod Methods That Are Unusual, F. H. Colvin. Am. Mach., vol. 71, no. 1, July 4, 1929, pp. 25–27, 6 figs. Description of combination of unusual fixtures and practice in machining Lynite rods and forged-steel caps of Stutz engines; methods vary considerably from standard practice.

Crankshafts. The Torsional Stiffness of Crankshafts, J. F. Alcock and H. S. Glyde. Automobile Engr. (Lond.), vol. 19, no. 255, June 1929, pp. 211–214, 13 figs. Problem of calculating torsional stiffness in crankshaft of high-speed engines is considered; deflections which occur in single crank-throw subjected to torsion; cases of single-throw crank with journals angularly free and with journals encastré; intermediate journals; cranks at 180 deg. flying web; general method of calculating natural period of oscillation of crankshaft; test figures correspond to critical speeds obtained by calculation.

Double Acting. A Double-Acting Engine. Automobile Engr. (Lond.), vol. 19, no. 254, May 1929, pp. 164–166, 9 figs. Description of new and interesting layout of double-acting engine designed for high speeds, which is one of three experimental Biga engines; Biga design compares favorably with orthodox practice as regards general accessibility; engine runs satisfactorily at speeds up to 5000 r.p.m.; components and inertia forces, inimical to fast running, are rendered harmless; functions of trunk pistons; temperature of cylinder walls; self-ventilating properties of Biga system.

Manufacture. Make Chevrolet Six-Cylinder Engine in Canada. Can. Machy. (Toronto), vol. 40, no. 13, June 27, 1929, pp. 95–96, 2 figs. Methods of manufacturing Chevrolet 6-cylinder engine in Walkerville plant of General Motors of Canada are briefly discussed.

Pressure Testing. Use of Electrical Pressure Indicators Limited in Automotive Tests, K. J. De Juhasz. Automotive Industries, vol. 60, no. 7, Apr. 27, 1929, pp. 622–664, 5 figs. Discussion of measurement of high-frequency pressure variations, such as occur in internal-combustion engines, by electrical methods; various shortcomings which may militate against their application to general testing of engines.

AUTOMOBILE MATERIALS

Felt Standards. Felt Specifications. Soc. Automotive Engrs.—Jl., vol. 24, no. 6, June 1929, pp. 650–651. Proposed S.A.E. Standard for felt specifications are given, which were studied by Subdivision of Standards Committee, under chairmanship of H. R. Wolf, of General Motors Corp. Research Laboratories.

AUTOMOBILES

Lubrication. Central Lubrication of Chassis Bearings, H. W. Pitt. Automobile Engr. (Lond.), vol. 19, no. 254, May 1929 pp. 187–192, 15 figs. Requirements of chassis-lubricating system are discussed; pipe distribution; advantages and disadvantages of different systems; Mercedes and Bosch engine-pump system; Allcyl, Stanley Oilmeter, and Bassick continuous-flow systems; Luvax-Bijur, Enots one-shot and Telcalemit intermittent pump systems; chassis oilways; design of front axles, spring shackles, flexible connections, and main piping.

Springs and Suspensions. Gyro-Accelerometer Analysis of Riding-Quality, M. L. Fox and T. J. Carmichael. Soc. Automotive Engrs.—Jl., vol. 24, no. 6, June 1929, pp. 626–632, 11 figs. Construction theory and some uses of Gyro-Accelerometer, for recording angular velocity, angular acceleration, and total angle turned; it is result of research into riding qualities of automobiles, conducted by Department of Mechanical Engineering at State University of Iowa; instrument furnishes analysis of angular movements whereby characteristics of springs and shock-absorbers can be so matched as to give body lowest values of angular acceleration and best riding quality.

AUTOMOTIVE FUELS

Coke. Coke as a Motor Fuel. Motor Transport (Lond.), vol. 49, no. 1268, July 1, 1929, p. 27, 2 figs. Results of tests made with Fordson tractor fitted with latest coke-using apparatus developed by Parker Producer Gas Plant Co.; gas generated in 1/4 of hr.; fuel costs compared.

B

BAKELITE

Machining. Bakelite and Some Notes on Machining It. Brit. Machine Tool Eng. (Lond.), vol. 5, no. 57, May-June 1929, pp. 240–242, 2 figs. Precautions necessary when machining bakelite are outlined, covering, turning, drilling, milling, sawing, threading, polishing, machining bakelite laminated sheet, cutting off, punching, machining laminated gear material, and piercing; physical properties of bakelite.

BERYLLIUM ALLOYS

Properties. Beryllium, a New Light Metal (Beryllium, ein neues Leichtmetall), Freitag. Motor (Berlin), vol. 17, no. 1, Jan. 1929, pp. 66–67. Beryllium has only recently been considered for commercial uses; impracticable to use it as pure metal because of its price; it is lighter than aluminum; iron with 2 per cent beryllium will attain 3 times its normal hardness and with appropriate heat treatment, 6 times normal hardness; iron with 4 per cent beryllium cannot be cold-rolled; copper with 6 per cent beryllium has hardness of hardened steel; these alloys are practically immune to corrosion and atmospheric effects.

BOILER FURNACES

Failures. Boiler Furnace Failures, A. A. Potter and H. L. Solberg. Power Plant Eng., vol. 33, no. 12, June 15, 1929, pp. 681–685, 11 figs. Deformation of firebrick at 25 lb. per sq. in.; failure of wall structure; clinker adhesion; spalling; comparison of maximum temperature of refractory with temperature of furnace gases near refractory piece; air-cooled furnace walls; water and steam-cooled furnace walls; curves showing effect of cold walls on flame temperature.

BOILER MANUFACTURE

Welding. Vertical Boilers With Welded Seams (Chaudières verticales à foyer intérieur assemblées par soudure autogène), è. Forgeot. Assns. Francaises de Propriétaires d'Appareils à Vapeur—Bul. (Mulhouse), vol. 10, no. 35, Jan. 1929, pp. 1–11, 13 figs. Construction details; dangers; enumeration of observed explosions and legal measures; article is followed by copy of Circular V from Ministry of Public Works to engineers and managers of mines regarding precautions in use of this type of boiler.

BOILERS

Oil Burning. The Combustion of Liquid Fuel, R. C. Vroom. Iron and Steel Engr., vol. 6, no. 6, June 1929, pp. 339–349, 15 figs. Application of combustion of liquid fuel is considered for firing furnaces of various kinds with special reference to use of liquid fuel for firing boilers; availability of fuel supply; development of burners; air and steam atomizers; mechanical atomizers, rotary cup and pressure types; oil pressure; viscosity regulation; blower and air register burners; impingement; furnace volume; refractory furnaces; air-cooled and water-cooled furnaces; refractory-faced water walls; forced and natural draft; preheated air; automatic control.

Pulverized Coal Fired, Ash Removal. Study of Some Factors in Removal of Ash as Molten Slag From Powdered-Coal Furnaces, R. A. Sherman, P. Nicholls and E. Taylor. Am. Soc. Mech. Engrs.—Advance Paper no. 25, for mtg. May 13 to 16, 1929, 12 pp., 11 figs. Investigation was conducted at Toronto, Ohio, station to study those factors governing application of slagging method of ash removal which are related to characteristics of ash of coal burned; results of observations made when burning three coals, whose ash had fluid temperatures of 2400, 2600, 2800 deg. fahr., in furnace fired with horizontal burners and having bare water tubes set on three walls.

Water Tube. Modern Developments of the Water-Tube Boiler for Marine Purposes, A. Spyer. Engineering (Lond.), vol. 127, no. 3298, Mar. 29, 1929, pp. 404–407, 9 figs.; see also Shipbldg. and Shipg. Rec. (Lond.), vol. 33, no. 13, Mar. 28, 1929, pp. 395–398, 4 figs. Progress in land work to obtain higher pressures and temperatures has been far more rapid than in marine work; while higher pressures and temperatures add to weight and cost, output required from steam-raising plant is diminished; introduction of water-tube boilers means reduction in weight of steam-raising plant; methods of firing; use of pulverized fuel. From paper before Instn. Naval Architects.

BRONZE

Bearing. The Recent Developments in the Testing and Applications of Bearing Bronzes, H. J. French. Can. Ry. Club—Official Proc. (Montreal), vol. 28, no. 2, Feb. 1929, pp. 21–40 and (discussion) pp. 41–52, 9 figs. Methods of test for bearing metals; metal mold vs. sand casting; properties of bronzes varying in tin and lead; effect of zinc on bronzes.

C

CARS

Refrigerator, Carbon Dioxide. Solid Carbon Dioxide for Railway Refrigerating Cars, J. W. Martin, Jr. Railroads (A.S.M.E. Trans.), vol. 51, no. 2, Jan.-Apr. 1929, pp. 5–7 and (discussion) 7–10. Advantages of this new product and savings effected by its use are discussed; it is opinion of many that solid carbon dioxide will help solve not only corrosion problem, but many other problems as well; problems found in design and operation of refrigerator cars.

CASE HARDENING

Carburizing. The Constitution of Steel and Cast Iron, F. T. Sisco. Am. Soc. Steel Treating—Trans., vol. 16, no. 1, July 1929, pp. 155–164, 2 figs. Operation of carburizing is discussed; low-carbon steels are used for carburizing because they give hard case and soft ductile core; chemical reactions taking place when steel is carburized with solid cements; various compounds commonly used; carburizing temperatures and depth and chemical composition of case.

CAST IRON

Alloy Classification. Classification of Gray Iron Alloys, J. W. Bolton. Am. Soc. Testing Matls.—Preprint, no. 35, for mtg. June 24–28, 1929, pp. 3–11, 4 figs. Five factors infleuncing properties of gray-iron castings are enumerated author advocates primary classification based upon chemical analysis, and secondary classification based upon cooling rate; in this latter connection he shows how mathematical formula can be applied to determine relative cooling rates of simple shapes.

Fatigue. The Fatigue Properties of Cast Iron, J. B. Kommers. Am. Soc. Testing Matls.—Preprint, no. 35, for mtg. June 24–28, 1929, pp. 35–43, 2 figs. Results obtained in testing four lots of cast iron at University of Illinois and ten different cast irons at University of Wisconsin; in Illinois tests, fatigue strength of cast iron was markedly increased by oft-repeated stress below endurance limit; in Wisconsin tests, ratio of endurance limit to tensile strength showed average value of 0.49; formulas are given by which maximum unit stress for various ratios of minimum to maximum stress may be computed approximately.

Properties. Effect of Section and Various Compositions on Physical Properties of Cast Iron, R. S. MacPherran. Am. Soc. Testing Matls.—Preprint, no. 35, for mtg. June 24–28, 1929, pp. 12–18, 7 figs. Study of effect of section on tensile strength and hardness of three types of cast iron: hard low-silicon gray iron, soft high-silicon gray iron, and high-test cast iron; whereas the two gray irons were appreciably harder at sides than at center, high-test iron here reported had practically equal Brinell hardness throughout; tensile strength of this iron decreases as thickness of bar increases.

CHROMIUM PLATING

Technique. Fundamental Factors Involved in Chromium Plating, L. Weisberg and W. F. Greenwald. Metal Cleaning and Finishing, vol. 1, no. 1, May 1929, pp. 85–88 and 112. Necessity of technical control in composition of solution is discussed; temperature of operation; current density; design of racks; relative cost of chromium plating and factors affecting cost.

CHROMIUM STEEL

Properties. Chromium as an Alloying Element in Steel, M. A. Grossmann. Am. Soc. Steel Treating—Trans., vol. 16, July 1929, pp. 165–170, 1 fig. Recommended Practice Committee release. Notes on metallic chromium, chromium in steel, source of chromium; chromium automotive steels; chromium-nickel, chromium - vanadium, chromium - molybdenum, chromium-silico-manganese steels; ball-bearing steels; air-hardening or self-hardening steels; high-speed and magnet steels.

COAL CARBONIZATION

Low Temperature. Low Temperature Carbonization, D. Brownlie. World Power (Lond.), vol. 11, no. 66, June 1929, pp. 607–612 and 614–615, 8 figs. Notes on following carbonization processes, with details of companies exploiting them: Babcock, Bussey, coalite, fusion retort, Hird, Illingworth, K.S.G., Laing-Nielsen, Maclaurin, Midland Coal products, Plassmann and Sutcliffe-Evans.

COAL DISTILLATION

Bussey Process. The Bussey Coal Distillation Process, H. B. Cronshaw. Engineering (Lond.), vol. 127, no. 3298, Mar. 29, 1929, pp. 409–411, 5 figs. Large plant for manufacture of smokeless fuel, oil, and gas by low-temperature system in course of erection at Glenboig, near Glasgow; will have output of 500 to 600 tons of coal per day, and daily output of 300 to 400 tons of smokeless fuel (semi-coke), 15,000 gal. of crude oil, and 15 million cu. ft. of gas; Bussey retort belongs to stationary, vertical-shaft, and internally heated type; consists of simple steel shaft lined with firebrick and supported on concrete base.

Products. Distillation Products of Coal. Nat. Elec. Light Assn.—Serial Report, no. 289–69, June 1929, 16 pp. Present status and future of low-temperature carbonization industry; statements contributed by F. Mueller, C. H. Lander, and Babcock and Wilcox Co.; distillation of power-plant coal; abstracts of papers presented before World Power Conference in London and before International Conference on Bituminous Coal, in Pittsburgh, on low-temperature plants and processes, by-products, and hydrogenation. 4-Page bibliography.

COKE

Research. Test for Measuring the Agglutinating Power of Coal, S. M. Marshall and B. M. Bird. Am. Inst. of Min. and Met. Engrs.—Tech. Publication, no. 216, 1929, 56 pp., 18 figs. Summary of different tests proposed by other investigators, discussion of factors affecting choice of procedure for agglutinating test; outline of procedure for making test; correlations of agglutinating values with characteristics of oven coke, and with constituents of coals. Bibliography.

CONVEYORS

Pneumatic. Pneumatic Conveyance by Fans, F. G. Whipp. Domestic Eng. (Lond.), vol. 49, no. 6, June 1929, pp. 103–110, 11 figs. Résumé of practice of fan conveyance based upon author's practical experience, including few examples of special and original schemes; fans for handling solid material; duct system; velocities to be maintained; pneumatic feeding of powdered coal.

COPPER ALLOYS

Properties. Hardness Relationships and Physical Properties of Some Copper Alloys, C. H. Davis and E. L. Munson. Am. Soc. Testing Matls.—Preprint, no. 47, for mtg. June 24–28, 1929, 12 pp., 11 figs. Hardness relationships of several commercial copper-zinc and copper-tin alloys, and three copper-nickel-zinc alloys were studied; evidence of tensile tests, and Brinell, Rockwell, and scleroscope hardness values on annealing and rolling series are assembled in tables of data and plotted in 11 charts; hardness-tensile strength relationship varies progressively with chemical composition and is also dependent on previous mechanical and thermal treatment to which any single alloy has been subjected.

CORROSION

Iron and Steel. A Critical Study of the A.S.T.M. Corrosion Data on Uncoated Commercial Iron and Steel Sheets, V. V. Kendall and E. S. Taylerson. Am. Soc. Testing Matls.—Preprint, no. 37, for mtg. June 24–28, 1929, 16 pp., 17 figs. Data resulting from atmospheric and total-immersion corrosion tests conducted by Society's Committee A-5 on Corrosion of Iron and Steel have been analyzed by statistical method to determine effect on corrosion resistance of copper, phosphorous, manganese, and sulphur, and their combinations; results are given in form of curves; under total-immersion conditions effect of ordinary variations in composition is secondary to external influences.

The Influence of Corrosion Accelerators and Inhibitors on Fatigue of Ferrous Metals, F. N. Speller, I. B. McCorkle and P. F. Mumma. Am. Soc. Testing Matls.—Advance Paper, no. 41, for mtg. June 24–28, 1929, 12 pp., 4 figs. Data reported follow report given last year in which marked influence of inhibitors in preventing corrosion fatigue was demonstrated; in present paper influence of wide range of chloride concentrations on corrosion fatigue of similar standard steel is reported, and influence of various amounts of inhibitors in retarding corrosion fatigue with same range of chloride concentrations.

Observation on the Corrosion of Iron, J. F. G. Hicks. Jl. of Phys. Chem., vol. 33, no. 5, May 1929, pp. 780–790, 4 figs. Primary cause of

corrosion of iron is actual dissolving of iron in water; this takes place before any other chemical action starts; film of water adhering to metallic surface undergoing corrosion is necessary to this dissolving process.

Repeated Stress. Corrosion of Metals Under Cyclic Stress, D. J. McAdam, Jr. Am. Soc. Testing Matls.—Advance Paper, no. 40, for mtg. June 24–28, 1929, 54 pp., 23 figs. Résumé of previous work, outline of continued investigation, and description of material and methods; effect of stress, time, and number of cycles on corrosion; metals investigated are ordinary steels, duralumin, monel metal, and stainless iron; "damage" as used in paper means lowering of fatigue limit due to corrosion with or without cyclic stress; net effect of cyclic stress on corrosion is illustrated by constant-net-damage diagram.

COST ACCOUNTING

Industrial. Translating Cost Data Into Cost Reduction, W. C. Rich. Am. Mgmt. Assn., no. 79, 15 pp. Operation of plan for conducting cost determination and cost reduction work, used by Minn. Steel and Machinery Co.; manufacturing costs have been reduced 40 per cent in $2^1/_2$ years resulting in year saving of approximately $1,200,000; manufacturing variations have been reduced 86 per cent by this plan.

COTTON MILLS

Humidity. Test Shows Effect of Constant Standard Humidity in the Cotton Mill, C. H. Forsaith. Textile World, vol. 75, no. 22, June 1, 1929, pp. 189–193, 1 fig. In order to test results of constant standard humidities, samples of cotton were taken before and after each step in process of manufacture, sealed in glass jars, and then baked out to note percentage of regain; results were plotted for convenience. Abstract of paper which was presented at Lowell Textile Inst.

CUTTING TOOLS

Diamond. Diamonds as Metal-Cutting Tools, C. L. Bausch. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. May 13–16, 1929, no. 2, 3 pp., 8 figs. See also Mech. Eng., vol. 51, no. 5, May 1929, pp. 360–362, 8 figs. History of use of diamond tools in plant of Bausch and Lomb Optical Co.; first used in turning of material too hard for steel tools; next use was in obtaining high finish on non-ferrous metals, and on work requiring extreme accuracy; in all cases high speed was obtainable, although heavy cuts have never been possible; data regarding selection and setting of diamonds in relation to cleavage plane of material, cutting speeds, and feeds, etc.

Metal-Cutting With Diamond Tools. Soc. Automotive Engrs.—Jl., vol. 24, no. 6, June 1929, pp. 634–635. Report of Subcommittee of Production Committee, based on questionnaire sent to manufacturers regarding applications of diamond cutting tools; life of diamond tools; machining connecting-rods and miscellaneous parts with diamond tools.

D

DIE CASTING

Dies. Die-Casting Dies of Recent Design, J. S. Gullborg. Machy. (N. Y.), vol. 35, no. 11, July 1929, pp. 809–815, 12 figs. Examples showing how ingenuity and skill of die designers and diemakers have helped to advance die-casting art; both ordinary machine steel and alloy steel are used for dies; general features of die construction; die for radiator cap of ornamental design; die for part having two inserts; die with unusually narrow gate; construction of dies for portable saw housings; design of dies for moving-picture parts.

DIESEL ENGINES

Compressorless. Indicated Efficiency of Compressorless Diesel Engines (Der indizierte Wirkungsgrad der kompressorlosen Dieselmaschine), F. Schmidt. V.D.I. Zeit. (Berlin), vol. 73, no. 18, May 4, 1929, pp. 617–619, 5 figs. Abstract of Bulletin 314 of Forschungsarbeiten des Vereines Deutscher Ingenieure; developing simple method for determination of indicated efficiency of compressorless engines; effect of various factors and results of tests of M.A.N. compressorless engine.

High Speed. Commercial Applications of High-Speed Oil Engines, C. H. Gibbons. Am. Soc. Mech. Engrs.—Advance Paper for mtg. June 24–27, 1929, 8 pp., 18 figs. Possible application of high-speed Diesel engines to aircraft, trucks, and tractors are discussed; details of their application to locomotives, generating sets for city buildings, cotton ginning, oil-well drilling, pipe-line pumping, irrigation, marine propulsion, air compressors, dredges, and excavating machinery; medium-speed applications also dealt with; data given for use in estimating power costs.

High Notes on High-Speed Oil Engines, H. O. Farmer. Diesel Engine Users Assn.—Report (Lond.), no. S-88, 1929, pp. 1–17 and (discussion), 17–25, 19 figs. Discussion of thermodynamical side of 4-stroke-cycle Diesel engine and comparison of performance with gasoline engine; lines along which design of combustion chamber will proceed; fuel injection systems and fuel values; principal problem is obtaining of sufficiently rapid ignition and combustion and difficulties are intensified when air is contaminated with larger percentage of exhaust gases, due to incomplete scavenging, which tends to retard rate of combustion.

High-Speed Diesel-Engine Design, O. Nonnenbruch. Am. Soc. Mech. Engrs.—Advance Paper for mtg. June 24–27, 1929, 6 pp., 3 tables. Designs of actually manufactured and commercially successful high-speed Diesel engines are compared; general picture of field to which Diesel engines may be applied, and conditions that have to be met in each field; weight per cu. in. displacement, mean effective pressure, and revolution per minute taken up; stroke-bore ratios compared with gasoline engines; raising revolution per minute by adequate means of fuel injection is real problem in high-speed Diesel-engine development; different systems of fuel injection.

History. Early History of the Diesel Engine, L. H. Morrison. Power, vol. 69, no. 26, June 25, 1929, pp. 1034–1038, 9 figs. Graph showing development of Diesel installation in United States; first Diesel put into commercial operation; design first used with two compressors driven from piston; Diesel designed by N. McCarty; two-stroke-cycle Diesel built by Standard Fuel Oil Engine Co.; America's first double-acting Diesel; early Hornsby-Ackroyd vaporizer engine; earliest large engine; Franchetti hot-bulb air-injection engine; Mietz and Weiss two-stroke-cycle hot-bulb engine.

Marine—Maintenance and Repair. Maintenance and Repair of Marine Diesel Engines, L. R. Ford. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. June 24–27, 1929, 8 pp., 10 figs. When operating under similar conditions, with equally competent engineers, Diesel plant requires less repair than steam plant but repairs that are required cost more; steam engine parts can be replaced at majority of ports, whereas part for Diesel must be sent from builder's plant; repair methods for bedplates, framing, cylinders, cylinder heads, crankshafts, connecting rods and crossheads, piston rods, pistons, valves and valve gear, cooling system, and fuel pumps are discussed.

Scavenging. Crank Case Scavenging of Two-Stroke-Cycle Engines, H. List. Nat. Advisory Committee for Aeronautics—Tech. Memorandum, no. 516, June 1929, 14 pp., 16 figs. Investigation of scavenging effect in two-stroke-cycle Diesel engine with crankcase scavenging; calculation of air consumption, efficiency of scavenging, length of exhaust port, and mean piston pressures; losses of scavenging air; five arrangements of scavenging ports; loop and through scavenging; scavenging efficiency increases nearly proportionally for all port arrangements and stroke-bore ratios with air consumption inside limits of 60 to 110 per cent. Translated from V.D.I. Zeit., Feb. 16, 1929.

DISKS

Rotating. Strength of High-Speed Rotating Discs of Various Sections, H. Yaskawa. Soc. of Mech. Engrs. of Japan—Jl. (Tokyo), vol. 32, no. 145, May 1929, pp. 199–209, 11 figs. General formulas for displacement equation of rotating disk; relation between stress and form of section developed; for practical example, result of stress calculation for film drum of Suhars' super high-speed kinetocamera is shown. (In English.)

DRIERS

Design. Design of Driers With the Aid of the J-d Diagram (Calcul des séchoirs accompagné du diagramme J-d), L. Ramzine. Chaleur et Industrie (Paris), vol. 10, no. 109, May 1929, pp. 219–229, 3 figs. Discussion of fundamental physical properties of humid air; humidity and heat balances of driers and their quantitative analysis; theory and uses of J-d (heat content and moisture content of air) diagram; theoretical and practical driers, their principal operating factors, economy, etc.; variations of normal drying process, by intermittent heating, etc. See Eng. Index, 1927, p. 271.

E

ENAMEL

Acid-Resisting. Study of the Properties of Simple Enamel Glasses, A. I. Andrews. Am. Ceramic Soc.—Jl., vol. 12, no. 6, June 1929, pp. 390–394, 8 figs. In research on development of acid-resisting dry-process cast-iron enamels, study was made of relation between composition and properties of simple enamel glasses; all enamels contain silica, alkalies, and either boric oxide or lead oxide; these oxides were chosen as those upon which to base fundamental study.

F

FEEDWATER TREATMENT

Embrittlement Prevention. Water Treatment to Prevent Embrittlement, F. G. Straub. Am. Water Works Assn.—Jl., vol. 21, no. 4, Apr. 1929, pp. 511–523, 3 figs. Results of research work being conducted at Engineering Experiment Station, University of Illinois; analysis of feed waters used in embrittled boilers; areas in United States in which boilers using well waters have been embrittled; analysis of water which embrittled boiler due to excess soda-ash treatment, or as result of zeolite treatment; methods of water treatment to prevent embrittlement; sulphate, tannate, and phosphate treatments.

Oil Removal. Removing Oil From Feed Water, F. Grove-Palmer. Power, vol. 69, no. 25, June 18, 1929, p. 1003. Dangers of oil present in form of emulsion in condensate and bulk of water are enumerated; analysis of condensate is suggested; application of oil separator; coagulation of oily emulsion by means of aluminum-sulphate solution.

FOUNDRIES

Cupola Design. Some Recent Developments in Cupola Design, F. K. Neath. Foundry Trade Jl. (Lond.), vol. 40, no. 665, May 16, 1929, pp. 368 and 358, 2 figs. Description of hot-blast cupola developed in America by Griffin Engineering Co.; use of powdered fuel as auxiliary fuel in cupola, and design of cupola developed for its use by American Radiator Co.; blast control; temperature measurement; thermocouple measurements.

G

GAS MANUFACTURE

Developments. New Developments in Gas Making, R. S. McBride. Chem. and Met. Eng., vol. 36, no. 6, June 1929, pp. 359–361. Editorial interpretation of new processes and technical trends revealed by Production Conference of American Gas Association; trends in water-gas industry are toward automatic manufacture, use of bituminous coal for solid fuel, and of propane and butane from natural gasoline for enrichment purposes.

GAS TURBINES

Lorenzen. Development of the Lorenzen Gas Turbine (Entwicklung der Lorenzen Gasturbine), B. Schulz. Motorwagen (Berlin), vol. 32, no. 17, June 20, 1929, pp. 355–359, 10 figs. Notes on exhaust-gas turbine for aircraft engines and for automobiles; pure-gas turbine of Lorenzen is based mainly on combination of turbine fed by combustion chamber with air-cooling blower.

GEARS AND GEARING

Bevel. Skew Bevel Gears, F. W. Shaw. Machy. (Lond.), vol. 34, no. 868, May 30, 1929, pp. 257–261, 5 figs. Discussion of fallacy of premise that elemental disks in contact must have constant-diameter ratio; construction of pair of conjugate hyperboloids described; elemental and conjugate disks; rack conjugate to all similar conjugate hyperboloidal surfaces is helicoidal surface which affords desired solution.

Design. The Use of Motion Pictures to Illustrate the Generation of Involute Gearing and the Use of Motion Pictures and Polarized Light as a Method of Studying Gear Stresses, W. H. Himes and R. V. Baud. Iron and Steel Engr., vol. 6, no. 6, June 1929, pp. 372–380, 15 figs. Development of involute gear; involute

rack; rack as gear-tooth generator; principles involved in photoelastic method; applications of photoelastic method to design problems in general and to gear problem; example of fillet problem.

Manufacture. Large Spiral Bevel and Hypoid Gears, A. H. Candee. Am. Soc. Mech. Engrs.—Advance Paper, no. 5, for mtg. May 13 to 16, 1929, 10 pp., 26 figs. Recent developments in manufacture of these gears discussed; improved running qualities of large bevel gears due to generating instead of planing teeth, and to use of spiral instead of straight teeth; Gleason bevel-gear generating machine with unique combination of mechanical movements to produce spiral teeth; accurate generation of large hypoid gears in which axis of pinion is offset from axis of gear.

H

HARDNESS TESTING

Brinell. Pitfalls in Brinell Testing. Mech. World (Manchester), vol. 85, no. 2214, June 7, 1929, pp. 534–535. While the Brinell testing may be very easily performed, its very simplicity and consistency of reliable results do on occasions lead to trouble and inaccuracies due to carelessness; various causes of inaccuracies in testing of steels for hardness are outlined.

Cloudburst Process. Cloudburst Process for Hardness Testing and Hardening, E. G. Herbert. Am. Soc. Steel Treating—Trans., vol. 16, no. 1, July 1929, pp. 77–92 and (discussion) 92–96, 15 figs. If piece of steel be placed in jet of hard steel balls moving at high velocity, balls will rebound from hard steel surface leaving it unaffected but will roughen soft surface; by this means exact shape and location of soft areas may be determined, whereas by present methods only one or few selected spots are tested; it is possible to superharden steel surface artificially by bombarding surface with hard steel balls; it is believed that process will be used to superharden gear teeth and other parts where extreme hardness is necessary.

Instruments. Busch-Schumann Projector for Reading of Brinell Hardness Ball Impressions (Der Busch-Schumann Projektor ein Ablesegeraet fuer Brinellsche Kugeleindruecke), Doehmer. V.D.I. Zeit. (Berlin), vol. 73, no. 22, June 1, 1929, p. 764, 2 figs. Detailed description of instrument for measuring depth of indentation with precision of 0.001 mm.

HEAT TRANSMISSION

Insulation. Thermal Insulation, P. Baunoux. Int. Bul. of Information on Refrigeration (Paris), vol. 9, no. 6, Nov.-Dec. 1928, pp. 1074–1078. Study is based on analogies of heat with electricity and comprises two parts; theory of heat transmission, and its application to insulators; bears principally on insulation of pipes. Abstract translated from Revue de l'École Polytechnique, Brussels, no. 7, 1928.

Surface. Surface Heat Transmission, R. H. Heilman. Am. Soc. Mech. Engrs.—Advance Paper for mtg. May 13–16, 1929, 10 pp., 9 figs. In view of dearth of reliable data on emissivity coefficients of various surfaces of lower temperatures met with in refrigeration and heat-insulation work, author undertook investigation of subject at Mellon Institute of Industrial Research, Pittsburgh; describes investigation and gives particulars regarding methods employed in determining surface coefficients; several charts are included.

HEATING

Hot-Air. Investigation of Warm-air Furnaces and Heating Systems, A. C. Willard, A. P. Krantz, V. S. Day. University of Ill. Bul., no. 189, vol. 26, no. 19, Jan. 1929, 116 pp. Among objects of investigation were to determine efficiency and capacity under actual conditions, methods of rating furnaces, methods of increasing efficiency, heat losses, proper sizes and proportions of leaders, stacks, and registers, friction losses, and to compare effects of outside and inside air circulation.

HYDRAULIC TURBINES

Rating. Mechanical Reliability of Hydro-Electric Units—1927. Nat. Elec. Light Assn.—Serial Report no. 289–68, May 1929, 13 pp., 3 figs. Report embodies results of four-year study and has been edited from reports of member companies; source and character, and general interpretation of data; number and rating of units; principal characteristics of hydroelectric units and operating records; average outage time classified by year of installation; analysis of outage hours; 1927 data; causes of outage in per cent of total outage time are shown in tables and graphs.

Regulation. Speed Regulation for Turbines (Les régulateurs de vitesse pour turbines), J. Levy. Technique Moderne (Paris), vol. 21, nos. 3 and 5, Feb. 1, and Mar. 1, 1929, pp. 65–69 and 133–141, 24 figs. Principles, methods, and apparatus used for speed regulation and measurement of speed and acceleration; general survey. Bibliography.

Research in Europe. Some Interesting European Hydraulic Turbine Research, B. R. VanLeer. Hydraulics (A.S.M.E. Trans.), vol. 51, no. 6, Jan.-Apr. 1929, pp. 57–64 and (discussion) pp. 64–66, 14 figs. Notes on work of European hydraulic-machinery laboratories; use of models; Thoma on hydraulic experimentation; efficiency formulas; draft-tube and cavitation research; features of Kaplan and Banki turbines; list of Kaplan installations in Europe; comparative efficiency curves of propeller, Francis, and Kaplan turbines and of Banki and Francis turbines; effect of submergence upon Banki turbines. Bibliography.

HYDROELECTRIC POWER PLANTS

Design. Details of Design and Construction of the Stream-Flow Power Plant, H. G. Roby. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 1, Jan.-Apr. 1929, pp. 3–4. Compromise between conflicts in requirements; limits in speeding up flow of water; adoption of propeller-type or high-speed runner; problems in design of Louisville hydroelectric plant. Paper presented before Midwest Power Eng. Conference.

Ice Control. Hydraulic Plant Operating Troubles Due to Low Temperatures, G. A. Hunt. Elec. West, vol. 62, no. 7, June 1, 1929, p. 571, 3 figs. Example of influence of freezing temperatures on operation of high mountain conduits in California, in Eldorado Canal of Pacific Gas and Electric Co. From report written for Hydraulic Power Committee, Pacific Coast Elec. Assn.

Operation. Hydraulic Plant Operating Troubles Due to Low Temperatures, G. A. Hunt. Elec. West, vol. 62, no. 6, May 15, 1929, pp. 386–390, 7 figs. Report prepared for hydraulic power committee of Pacific Coast Electric Assn. describes types and characteristics of ice formation and shows how ice interferes with normal operation of hydroelectric equipment in cold climates; data outlining practices and remedial measures developed in this regard in Norway, Sweden, Canada, and in eastern United States.

I

ICE PLANTS

Rating. Can Ratio and Rating of Ice Plants, M. K. Knoy. Refrigeration, vol. 45, no. 6, June 1929, pp. 41–44, 3 figs. Can ratio in ice plant is total number of cans employed divided by tons of ice made per day; this ratio depends upon following factors: size and thickness of ice block, brine temperature carried, nature of agitation, temperature of can water and core-filling water, and can submergence, each of which is discussed.

IMPACT TESTING

Notched Bar. The Notched-Bar Impact Test, F. Fettweis. Metallurgist (Supp. to Engineer, Lond.), June 28, 1929, pp. 94–96, 4 figs. Summary of existing knowledge of notched-bar impact test; relation between impact figure and tensile properties; strained region of notched-bar test piece; defects of notched-bar test. Abstract translated from Archiv. fuer das Eisenhuettenwesen, Apr. 1929, previously indexed.

Repeated Blow. Repeated Blow Impact Tests, R. H. Greaves. Metallurgist (Supp. to Engineer, Lond.), June 28, 1929, pp. 88–90, 5 figs. Investigation made to determine what extent brittleness revealed blow impact tests on notched bars; assuming that tensile and single-blow notched-bar test have been made on a material, it is doubtful whether results of repeated-blow tests add any information of value; test, however if it is carried out, is too complex to have any simple quantitative significance. (Concluded.)

INDUSTRIAL ORGANIZATION

Functionalization. The Pros and Cons of Functionalization, J. Lee. Taylor Soc.—Bul., vol. 14, no. 3, June 1929, pp. 114–119. Functional divisions come from that conception of scientific management which believed that organization should be focused upon functional divisions; in Taylor's scheme there were to be 8 foremen each with his own function; this extreme doctrine has largely been surrendered and functional division takes part which can best be called coordinated part in organization.

INTERNAL-COMBUSTION ENGINES

[See AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES.]

IRON AND STEEL PLANTS

Waste Heat Recovery. Waste Heat in the Steel Industry, G. R. McDermott. Engr's. Soc. of West. Pa.—Proc., vol. 45, no. 4, May 1929, pp. 195–199 and (discussion) 199–203. General aspects of available sources and methods employed for recovering waste heat in steel industry; determining available waste heat of given furnace for purpose of preheating air for boiler utilization; limitations in recuperators and air preheaters in metallurgical furnaces; heat transmission and boiler design; utilization of waste heat leaving open-hearth furnace for steam generation.

L

LOCOMOTIVE BOILERS

Corrosion Prevention. Combating Boiler Corrosion, C. H. Koyl. Boiler Maker, vol. 29, no. 6, June 1929, pp. 164–165. Presence of caustic soda in treated waters has nearly annihilated corrosion of all kinds; use of soda-ash on hard-water division between Perry, Ia., and Council Bluffs, Ia., has nearly done away with pitting; open feedwater heaters on these other divisions have not received care bestowed by original crew on first open heater placed four years ago on Sioux City Division. Paper presented before Master Boiler Makers Assn.

LOCOMOTIVE PLANTS

Hydraulic Machinery. Hydraulic Power at the Baldwin Works, J. M. Combs. Iron Age, vol. 123, no. 25, June 20, 1929, pp. 1696–1698, 7 figs. Extensive use of hydraulic machinery in new plant of Baldwin Locomotive Works at Eddystone, Pa.; delicate as well as massive tools required; operation of 1400-ton flanging and 800-ton bending presses.

LOCOMOTIVE REPAIR SHOPS

Machine Tools. Machining Heavy Parts in C. P. R. Angus Shops at Montreal, W. H. Martin. Can. Machy. (Toronto), vol. 40, no. 27, May 30, 1929, pp. 27–30, 10 figs. Operations and equipment used in Angus shops of Canadian Pacific Railway for machining parts of locomotive; Godfrey oxygen jet-cutting machine; drilling machines for heavy parts.

LOCOMOTIVES

High-Pressure (Schmidt). The Schmidt High-Pressure Locomotive of the German State Railway Company, R. P. Wagner. Railroads (A.S.M.E. Trans.), vol. 51, no. 2, Jan.-Apr. 1929, pp. 29–37 and (discussion) 37–47, 11 figs. Details and road-test data of locomotive having boiler which generates steam at two pressures, 850 and 205 lb., using 850-lb. in center cylinder, and its exhaust, mixed with 205-lb. steam, in two outside cylinders.

Welded. Mikado Type Locomotive for the Georgia Northern. Ry. Age, vol. 86, no. 26, June 19, 1929, pp. 1552–1554, 6 figs. Welding of locomotive and tender-frame connections eliminates many bolts and rivets; welded construction of 95-ton, 2–8–2 Baldwin locomotive.

LUBRICANTS

Cutting. Selecting the Right Cutting Lubricant, H. L. Kauffman. Machy. (N. Y.), vol. 35, no. 11, July 1929, pp. 857–860. Cutting lubricants are classified according to characteristics and points to consider in selecting them are discussed; reduced cutting friction; cooling properties of lubricant; washing or flushing effect of lubricant; straight cutting oils; characteristics of vegetable and animal oils; advantages gained by mixing oils; compounding animal and mineral oil; water-soluble oils; selecting cutting lubricants to suit cutting speed and depth of cut; application of water-emulsifiable cutting oil; application of water-soluble cutting emulsion.

M

MACHINE TOOLS

Replacement. What Obsolete Equipment Costs. Am. Mach., vol. 71, no. 1, July 4, 1929, pp. 1–4, 3 figs. Discussion of how much machine-tool plant lost by not replacing three

obsolete machines; costs estimates are given for three machine tools which would have saved $20,000 a year; Warner and Swasey, SKF, and A.S.M.E. formulas used.

Vibrations Balancing. Machine Shop Balancing Problems. Can. Machy. (Toronto), vol. 40, no. 27, May 30, 1929, p. 31. Causes of vibration in machine tools are discussed; rolling resistance; improved balancing way is pair of free running disks in place of each of flat rails; neutralizing agitating effect.

MANGANESE STEEL

Heat Treated. Heat-Treated Low-Manganese Steels, E. E. Thum. Iron Age, vol. 123, no. 25, June 20, 1929, pp. 1691–1695, 5 figs. Applications of heat-treated low-manganese steels are discussed, covering shock-resisting castings, anchor chain, high-test welding rod, carburizing steel, heat-treated forgings, bolts for high-temperature steam valves, rifle barrels, leaf and helical springs, shear blades, and gages (non-deforming); oil quenched and drawn castings, forgings and machined parts of intermediate properties and costs becoming popular in American shops.

METALS

Creep. A Machine for Making Creep Tests at High Temperatures, G. D. Bagley. Am. Soc. Mech. Engrs.—Advance Paper, no. 1, for mtg. May 13 to 16, 1929, 3 pp., 4 figs. Description of apparatus developed by Union Carbide and Carbon Research Laboratories for making high-temperature creep tests; compound lever system of applying load makes it possible to determine load accurately and to use standard 0.505-in. diam. specimens without employing excessive weights, even at relatively low temperatures; simplified method of measuring extension of specimens.

Ductility. Some Developments in Ductility Testing, C. N. Fletcher. Machy. (Lond.), vol. 34, no. 870, June 13, 1929, pp. 336–337, 5 figs. Details of large machine manufactured by Olsen suitable for ductility testing of materials; up to $^1/_4$-in. thickness with maximum load of 35,000 lb. cupping being automatically measured by dial gage to 0.001 in. load measured hydraulically and rupture point is noted by instantaneous drop of pressure; Olsen, lever weighing type, ductility testing machine; tools employed on Olsen lever weighing type ductility testing machine; Olsen Williams dynamic ductility testing machine.

Hardening. Cold and Hot Working of Metals, W. Rosenhain. Rolling Mill Jl., vol. 3, no. 5, May 1929, pp. 215–217. Bearing of recent results in testing of creep and work softening of metals on present theories of work hardening and plastic deformation discussed; influence of irregular intercrystalline structure on behavior of metal during deformation; limit of work hardening; work hardening due to lattice distortion; crystal junctions. Abstract of paper presented before Int. Congress for Testing Matls.

Proportional Limit. The Determination and Significance of the Proportional Limit in the Testing of Metals, R. L. Templin. Am. Soc. Testing Matls.—Preprint, no. 90, for mtg. June 24–28, 1929, 12 pp., 6 figs. Discussion of factors affecting proportion limit; attempts to give idea of quantitative effects of various factors on proportional limit; numerous stress-strain diagrams for series of tension test specimens $^1/_2$ in. in diam. all prepared from same material, but tested under different conditions, are given; it appears that so-called yield point is appreciably easier to determine on routine commercial testing basis than proportional limit and probably is adequate for needs of designer and for product specification purposes.

Testing. The Mechanical Testing of Materials, R. W. Bailey. Metropolitan-Vickers Gaz. (Manchester), vol. 11, no. 194, May 1929, pp. 266–275, 24 figs. Testing methods for discovery of defects; magnetic methods; principle iron-dust test; arrangement of magnetizing apparatus for crack detection in gear pinions; apparatus and form of test piece in embrittlement test; embrittling effect of high temperature on $3^1/_2$ per cent nickel steel subjected to stress; abrasion testing machine; turbine blades under vibration.

MOTOR BUSES

Acceleration. Acceleration Rates Compared for Gas-Electric and Mechanical Drive Buses, W. H. McLaughlin. Elec. Ry. Jl., vol. 73, no. 16, July 1929, pp. 699–700, 2 figs. Tests made by Westinghouse Electric and Manufacturing Co. on chassis equipped first with one type of drive and later with other; results are graphically compared as same engine was used throughout and difference in total weight represents fundamental difference between conditions of tests.

Brakes. Maintaining a Standard Efficiency of Brakes, M. W. Bourdon. Bus and Coach (Lond.), vol. 1, no. 3, Mar. 1929, pp. 110–114, 9 figs. Importance of insuring uniformity of effect of brakes with relation to effort is discussed, with suggestions as to routine and means and method for repairing brakes on motor buses.

Crack Detectors. Detecting Cracks With Magnet. Elec. Traction, vol. 25, no. 5, May 1929, p. 252–253, 2 figs. Operators may guard against fracture of bus parts with new electromagnetic crack detector which is described.

Design of Bodies. Tendencies of This Season's Long Distance Coach Bodies, P. M. A. Thomas. Bus and Coach (Lond.), vol. 1, no. 4, Apr. 1929, pp. 147–151, 13 figs. Trend in motorbus body design is taken up; bodies not more luxuriously furnished than last season; lavatories and buffets criticized; longitudinal seatover wheel arches eliminated; exterior appearance; roof design; rear panels; insufficient leg room; comfortable seats; adjustable backs; lighting interiors; fittings good and bad.

MOTOR TRUCKS

Bodies. Aluminum Alloy Bodies for Trucks Possess an Economic Advantage, P. M. Heldt. Automotive Industries, vol. 60, no. 25, June 22, 1929, pp. 938–939 and 945, 3 figs. Economic advantages of aluminum bodies for motor trucks are discussed; their use has been largely credited to incentive for overcoming legal restrictions imposed upon gross weight of vehicles using highways; aluminum body costs more than steel or composite body; analysis of possible savings in actual case of Chicago coal company, which owns number of $7^1/_2$-ton trucks.

Maintenance and Repair. The Maintenance Problem of the Mixed Truck Fleet, K. H. Lansing. Power Wagon, vol. 42, no. 294, June 1929, pp. 54–56 and 58. Discussion of considerations influencing motor truck fleet operator in determining type of units he shall purchase and how they shall be maintained; well-equipped machine shop with staff of expert mechanics is preferable to factory branch, distributor, or dealer service station for repairing trucks.

Springs and Suspensions. Can Suspension Be Improved? Motor Transport (Lond.), vol. 48, no. 1263, May 27, 1929, p. 619. Principal factors affecting realization of ideal suspension system for motor trucks, and shortcomings of those in use at present are discussed; advantages derivable from having each wheel independently sprung are outlined.

N

NICKEL ALLOYS

Constitution. Constitution of Nickel-Carbon Alloys, N. B. Pilling and T. E. Kihlgren. Am. Soc. Steel Treating—Trans., vol. 16, no. 1, July 1929, pp. 171–172, 1 fig. Recommended Practice Committee Release. Carbon has limited solubility in molten nickel; addition of carbon to nickel progressively lowers melting point from 1452 to 1318 deg. cent., at which temperature eutectic is formed with 2.2 per cent carbon, carbon appearing as graphite; equilibrium for carbon concentrations greater than 2.2 per cent has not been satisfactorily worked out and data are meager; carbon evidently has little effect on vapor pressure of nickel. Bibliography.

NITRIDATION

Steel. Nitriding, V. O. Homerberg. Black and White (Metal Edition), vol. 2, no. 1, June 1929, pp. 12–18, 7 figs. Development of nitriding by Fry in Krupp Works, Germany, is outlined; tables of analysis of physical properties of three nitralloy steels after proper heat treating and before nitriding; limitations of nitriding process.

The Nitride Hardening of Steel. Metallurgist (Supp. to Engineer, Lond.), Apr. 26, 1929, pp. 63–64. Nitriding consists essentially of heating specimen or part for definite period of time at temperature of 500 deg. cent. in atmosphere of ammonia; in order to meet different requirement of core strength for different purposes, range of steels, termed nitralloy steels, which contain aluminum, has been developed.

O

OFFICE BUILDINGS

Air Conditioning. Air Conditioning System of a Detroit Office Building, H. L. Walton and L. L. Smith. Heating, Piping and Air Conditioning, vol. 1, no. 1, May 1929, pp. 43–48, 9 figs. Union Trust Building, having 16 stories and 2 basements is heated and ventilated throughout by combined air-conditioning and heating system; air conditioning operating costs are given.

Refrigeration and Ventilation as Aids to Natural Efficiency, S. C. Bloom. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 1, Jan.-Apr. 1929, pp. 33–35. Development in air cooling and air circulation incorporated in modern office buildings; 50 to 75 per cent of air used recirculated and recooled; volume sufficient to change air of building five to eight times per hour; cooling is required but small part of year and yet refrigerating equipment provided of capacity sufficient to handle peak load; power demand high and intermittent and much expensive apparatus must remain idle part of time. Paper presented before Midwest Power Eng. Conference.

Refrigeration. Refrigeration Is Necessary Part of Office Building. Power, vol. 69, no. 25, June 18, 1929, pp. 1008–1010, 5 figs. New York Life Insurance Co. uses 100-ton plant to supply drinking water, make ice cream and permit food storage; Brine system is applied; features of switchboard.

OIL WELL DRILLING

Crooked Holes. Symposium on Straight Hole Methods, W. K. Whiteford. Oil and Gas Jl., vol. 28, no. 3, June 6, 1929, pp. 49, 167–168, 170, 172, and 174. See also Nat. Petroleum News, vol. 21, nos. 23 and 24, June 5 and 12, 1929, pp. 37–41 and 56–57, 59 and 60, 1 fig. Proper weight to use in drilling straight rotary hole, ranges from 7000 lb. per sq. in. for shale to 12,000 for lime, with 6-in. drill pipe in greater Seminole area; speed of rotation 35 to 50 r.p.m. for shale and 50 to 80 for lime; consistency of mud fluid is important in prevention of crooked holes; details of equipment and drilling operations. Compilation of data supplied by contractors, operators, and manufacturers. Read before Am. Petroleum Inst.

Equipment. Oil-Well Drilling Equipment, F. W. Curtis. Am. Mach., vol. 70, no. 25, June 20, 1929, pp. 979–982, 9 figs. Group of machining operations employed by Doheny Stone Drill Co., Torrance, Calif., is described; methods used to secure accuracy in joints of shaft that connects drilling machine to cutter head mile or more below.

P

PETROLEUM REFINING

Cracking. Some Aspects of Cracking, A. E. Dunstan and R. Pitkethly. Indus. and Eng. Chem., vol. 21, no. 7, July 1929, pp. 643–647, 2 figs. Modern cracking processes and their limitations; method for minimizing coke problem; comparison of liquid- and vapor-phase cracking; chemical aspects of cracking; apparatus for studying effects of cracking; fundamental research of American Petroleum Institute. Bibliography.

Edeleanu Process. Technology and Economy of the Edeleanu Process of Petroleum Refining (Technik und Oekonomie des Edeleanu-Verfahrens zur Raffination von Mineraloelen), G. Cattaneo. Waerme u. Kaelte-Technik (Erfurt), vol. 31, no. 5, Mar. 18, 1929, pp. 3–8, 7 figs. General principles of process; arrangement of apparatus; curves of vapor pressure, temperature, and concentration of sulphur dioxide; modification of process to suit conditions in United States. Paper read before German Soc. of Refrig. Engrs.

Silica Gel. The Refining of Light Oil With Gel at Rochester, N. Y., R. E. Fulreader. Indus. and Eng. Chem., vol. 21, no. 7, July 1929, pp. 691–693, 1 fig. Silica-gel plant has been in operation since Mar. 1, 1927; it was designed to treat uncut crude light oil having end point ranging from 428 deg. cent. to 536 deg. fahr.; plant has never shown oil less in excess of 3 per cent.

PIPE

Steel, Manufacture of. Manufactures Riveted Steel Plate Water Pipe Progressively, E. L. Shaner. Iron Trade Rev., vol. 84, no. 25, June 20, 1929, pp. 1653–1657, 9 figs. Description of scheme of progressive manufacture which has been applied to steel pipe fabrication in plant of Witt-Humphrey Steel Co., South Greensburg, Pa.; growing demand for large sizes in quantity has developed methods for mass production; asphaltum coating is applied after riveting; riveters served by cranes; multiple

automatic punch consisting of two opposed gang punches with hand-operated spacing table between.

PIPE LINES

Electric Welding. Welding 26 Miles of Pipe a Day. Iron Age, vol. 124, no. 2, July 11, 1929, pp. 92–94, 5 figs. Methods employed by A. O. Smith Corp., Milwaukee, for electric welding of pipe at rate of 26 mi. in 24 hr.; use of automatic equipment, both processing and conveying; conveyors pick up pipe at outgoing end of welding machines and carry it to milling machines; hammer test is applied automatically; conveyors are timed and automatically loaded.

POWER PLANTS

Corrosion. The Corrosion Problem as Applied to Power Plants, R. S. Rawdon and K. H. Logan. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 1, Jan.-Apr. 1929, pp. 19–24, 7 figs. Discussion of corrosion problem as it relates both to inside and outside of power plant, that is, to generating of power and to its transmission; boiler corrosion and water treatment; extent to which corrosion of boiler and allied equipment can be controlled by wise choice of material; corrosion from furnace combustion products; corrosion of overhead and underground transmission lines; failures of reinforced concrete. Paper presented before Midwest Power Eng. Conference.

Purchased vs. Generated Power. Purchasing Public Utility Power for Industrial Use, W. B. Skinkle. Engrs. Soc. of West. Pa.—Proc., vol. 45, no. 2, Mar. 1929, pp. 57–81 and (discussion) 81–106, 12 figs. Ever-increasing number of industries are becoming customers of, and are depending on, various public-utility power companies for their main, and often sole, source of primary power, author examines subject, analyzes economics of situation, particularly from the standpoint of the purchaser of electric energy.

PRODUCTION CONTROL

Process Charts. Controlling the Manufacture of Parts on Order and for Stock by the Gantt Progress Chart, D. B. Porter. Am. Soc. Mech. Engrs.—paper for mtg. Feb. 4, 1929, 5 pp., 4 figs. Two special applications of Gantt process chart are explained; first, plan for manufacture and assembly of parts on order and second, case where manufacturing for stock is already in process; methods for laying out carts fully explained.

PUBLIC UTILITIES

Materials Handling. The Materials-Handling Problem in the Public Utility, J. C. Somers. Matls. Handling (A.S.M.E. Trans.), vol. 51, no. 3, Jan.-Apr. 1929, pp. 25–28 and (discussion), p. 28. Definite attempt to summarize problem in general terms with specific reference to central-station industry; investment in materials handling equipment given in table; engineering organization; methods of procedure; function and uses of equipment; conditions of installation and use; means of operation; general considerations regarding costs; order of preference as to expenditures.

PUMPS, CENTRIFUGAL

Corrosion. Corrosion of Centrifugal Pumps (Korrosionen bei Zentri-fugal-pumpen), W. Mueller. Korrosion u. Metallschutz (Berlin), vol. 5, no. 3, Mar. 1929, pp. 59–61, 7 figs. Corrosion is due to chemical, chemico-mechanical, and electrical influences, each of which is discussed, and means of prevention suggested.

Dredge. Dredge-Pump Pressures and Thrust Loads, J. H. Polhemus and J. Healy. Hydraulics (A.S.M.E. Trans.), vol. 51, no. 6, Jan.-Apr. 1929, pp. 33–40 and (discussion) 40–48, 13 figs. Results of dredge-pump pressure tests on Diesel-electric 30-in. 2700-hp. dredge Clackamas, by Port of Portland engineering staff; effect of varying lengths of pipe line, impeller clearances and impellers with and without relief holes in back shroud; determination of smallest bearing that would amply take care of maximum thrust loads; unknown variable-thrust load factors; relative pressure within pump casing; effect of pump horsepower, speed, suction, pumping material, etc.

Theory. Centrifugal-Pump Economics, A. F. Scherzer. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 1, Jan.-Apr. 1929, pp. 47–52, 7 figs. Some developments in theory of centrifugal pumps and their application to practice; performance shown best by quantity-head curve; wide difference between theoretical curve and tests; discovery of surprising error in derivation of fundamental theory; use and benefits claimed for guide vanes are founded on misconception in theory. Paper presented before Midwest Power Eng. Conference.

R

RAILROADS

Maintenance and Repair. The Western Pacific Dresses Up. Ry. Age, vol. 86, no. 25, June 22, 1929, pp. 1416–1422, 13 figs. Entire line under vigorous improvement program; machine methods save labor and speed work; bank widening by machine; ballasting methods; spikes driven by air; weld battered joints; good homes for labor.

RAILS

Fracture. On the Question of Resistance of Rails Against Breakage and to Wear; Rail Joints, R. B. Abbott. Int. Ry. Congress Assn.—Bul. (Brussels), vol. 11, no. 5, May 1929, pp. 483–501, 3 figs. First causes of rail breakage; measures taken to reduce number of breakages, both as regards way rails are used and conditions of inspection; quality of metal used for rails to give normal wear; conditions governing manufacture and inspection; rail joints; most economical and efficient design; answers to questionnaire from main railroad companies of United States and Argentina.

RAYON MANUFACTURE

Bagasse Utilization. Utilization of Bagasse for the Manufacture of Artificial Silk. Int. Sugar Jl. (Lond.), vol. 31, no. 365, May 1929, pp. 277–279. Bagasse used was from Trinidad, and consisted of fibrous chips and crushed cane in pieces of irregular size up to 5 in. in length; owing to presence in material of pithy matter, material was subjected to mechanical treatment with view to its separation before digestion; fibrous material was then treated with caustic soda under conditions similar to those employed commercially for production of pulp. Abstract from Bul. of the Imperial Inst. no. 1, 1929.

RAYON PLANTS

Odors. The Emission of Fumes From Artificial Silk Works. Chem. Age (Lond.), vol. 20, no. 519, June 8, 1929, pp. 47–48. Report by chief inspector of Alkali Works; odors and gases from viscose works; attempts to obviate odor; suggested lines of investigation; nature of viscose process; origin of odor; ventilation; effluents from viscose works; health hazards.

REFRACTORY MATERIALS

Silica. Silica as a Refractory in the Steel Industry, R. B. Sosman. Am. Iron and Steel Inst.—Advance Paper, for mtg. May 24, 1929, 31 pp., 12 figs. Silica as raw material; discussion of melting points of refractories; thermal inversions and expansions; relations of silica to other oxides; value of, and outlook for, research and experimentation.

REFRIGERATION

Ammonia Metering. The Importance of Precooling Metered Ammonia, R. C. Connet. Ice and Refrigeration, vol. 76, no. 6, June 1929, pp. 541–542, 3 figs. Difficulties of adapting liquid flow meters in connection with refrigeration work overcome by precooling ammonia, thus eliminating trouble due to liquid being part liquid and part gas at metering points; subject discussed by member of engineering staff of Builders Iron Foundry.

REFRIGERATING MACHINES

Absorption. The Calculation of the Absorption Machine, Merkel. Int. Bul. of Information on Refrigeration (Paris), vol. 9, no. 6, Nov.-Dec. 1928, pp. 1051–1062, 8 figs. In majority of technical processes accompanied with displacements of heat, establishment of heat balances by considering heat content or total heat leads to particularly simple and clear processes of calculation; author seeks to demonstrate that this mode has great advantages in case of absorption machines. Abstract translated from Zeit. fuer die gesamte Kaelte-Industrie, July 1928.

ROCKET PROPULSION

Theory of. Thermodynamics of Rockets (Thermodynamik der Rakete), A. B. Scherschevsky and W. Ley. Maschinen-Konstrukteur (Leipzig), vol. 62, no. 6, Mar. 15, 1929, pp. 129–130. Theoretical mathematical discussion. Bibliography.

RUBBER COMPOUNDS

Testing. The Use of a Group of Performance Tests for Evaluating Rubber Compounds That Must Withstand Repeated Compression, H. A. Depew and E. G. Snyder. Am. Soc. Testing Matls.—Advance Paper, no. 87, for mtg. June 24–28, 1929, 11 pp., 6 figs. Test methods for evaluation of solid tire compounds are described in detail; they consist in preparing two test cylinder of rubber 5 in. in diameter and $3^3/_4$ in. high for each cure, and vulcanizing over range of cures; data is given comparing two solid tire compounds of different sulphur contents.

RUBBER TIRES

Standardization. Tires and Rims. Soc. Automotive Engrs.—Jl., vol. 24, no. 6, June 1929, pp. 638–642, 1 fig. Review of meeting of Tire and Rim Division of Standards Committee; proposed S.A.E. Standard for pneumatic tires and rims and balloon tire and rims for commercial vehicles, solid-tire base bands, solid tires, balloon tires and rims for passenger cars and cushion tires, hollow center; proposed S.A.E. recommended practice for dual spacing for truck and bus high-pressure and balloon tires, truck and bus high-pressure tire load and inflation, passenger-car balloon-tire load and inflation, and truck and bus balloon-tire load and inflation.

S

SCRAP METAL

Recovery and Use of. Secondary Metals, J. P. Dunlop. U. S. Bur. of Mines—Mineral Resources of United States, no. 1:16, Apr. 4, 1929, pp. 373–392. Recovery, treatment, and use of waste material; classification of old metals; review of secondary metal industry in 1927; market conditions; secondary copper, lead, zinc, tin, antimony, aluminum, and nickel.

SHAFTS AND SHAFTING

Critical Speed. Shaft Behavior at Critical Speed, H. D. Taylor. Gen. Elec. Rev., vol. 32, no. 4, Apr. 1929, pp. 194–200, 12 figs. Characteristic behavior shown by small model; marked reduction in violence of critical-speed disturbance obtained by accurate balancing; theoretical reversal of bending of shaft in passing through critical speed confirmed by marking shaft; stroboscopic apparatus for measuring angle of lag; comparison of theoretical curves with test observations; appendix; derivation of formulas.

Vibration. Shaft Vibration (Tengelyek rezgese), P. Halasz. Electrotechnika (Budapest), vol. 22, nos. 7–8, Apr. 15, 1929, pp. 63–78, 26 figs. Necessity of vibration in shafts; factors producing and influencing oscillation; methods of calculation and prevention of vibration.

SOLDERS

Lead-Tin-Cadmium. Lead-Tin-Cadmium as Substitute for Lead-Tin Wiping Solder, E. E. Schumacher and E. J. Basch. Bell Telephone Laboratories—Reprint, no. B-369, Feb. 1929, 8 pp., 2 figs. Data showing path that certain lead-tin-cadmium alloys may be advantageously substituted as solders for lead-tin alloys; physical and chemical properties of these alloys are discussed.

STEAM CONDENSERS

Heat Transmission. Heat Transfer From Steam to Metal, D. F. Othmer. Engineering (Lond.), vol. 127, no. 3309, June 14, 1929, pp. 745–746. Account of study made at University of Michigan; method of conducting test; equations are recommended for rate of heat transfer from steam to metal; heat transfer is not independent of actual steam temperature which is mainly due to variation in viscosity of film of water which always forms on surface of condensing tube.

STEAM POWER PLANTS

Ash Handling. Does Slag Tapping Solve the Ash Problem? Power Plant Eng., vol. 33, no. 12, June 15, 1929, pp. 686–690, 3 figs. Introduction of molten-slag method of removing pulverized fuel ash from furnace showed notable development which is being widely adopted; experience with this method at Charles R. Huntley station of Buffalo General Electric Co., where comparatively low-fusion ash coals are burned; layout of hydro-jet system which has been successful there and at Toronto Station of Pennsylvania Ohio Power and Light Co. are described.

Design. Economic Pressure in Steam Condensing Power Plants (Der wirtschaftliche Druck von Kondensationsdampfkraftanlagen), R. Doczekal. Sparwirtschaft (Vienna), vol. 7, no. 4, Apr. 1929, pp. 196–198, 4 figs. Theoretical cost analysis tracing effect of price of coal and thermal efficiency on determination of most economic pressure.

Foreign Developments. Nat. Elec. Light Assn.—Serial Report, no. 289-64, May 1929, 31 pp., 29 figs. Statements by American and foreign engineers covering detailed engineering developments; abstracts from foreign journals are included; opinions expressed in these state-

ments are quite specific and indicate general trend of steam-power-plant development in foreign countries.

High Pressure. To Reduce Power Costs, St. Loeffler. Elec. World, vol. 93, no. 17, Apr. 27, 1929, pp. 829–830, 1 fig. Maximum limit of 2200 lb. at 1000 deg. fahr. is advocated; forced steam-circulation system developed by author makes safe, simple, and cheap power station; utility point of view of station building.

Metals. Metals Used in Power Plants, A. E. White. Fuels and Steam Power, vol. 51, no. 1, Jan.-Apr. 1929, pp. 11–18, 16 figs. Cast iron, wrought iron, plain carbon steels, certain selected alloy steels, copper, lead, brass, bronze, babbitt, and monel, and field of use of each of these materials in power-plant work considered; tests to determine suitability for power-plant use; visual and microscopic examination; tensile, impact, and hardness tests; metallographic examination; magnetic tests; X-ray examination; strain determinations; heat, fatigue, corrosion, corrosion-fatigue, and high-temperature tests. Paper presented before Midwest Power Eng. Conference.

STEAM TURBINES

Design. Commercial Problems in Steam-Turbine Design, R. C. Allen. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 1, Jan.-Apr. 1929, pp. 45–46. Developments in steam-turbine design; concentration of power in modern turbines has led to increase of operating stresses of turbine parts; tendency toward higher blade speeds and reduced size and cost of machines; manganese copper used for blades of low stress and of small size; for larger and more important blades stainless steel is used which can be forged and machined without difficulty. Abstract of paper presented before Midwest Power Eng. Conference.

High Pressure. High-Pressure Turbine Installation of Kansas City Power and Light Company, E. Jowett. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 1, Jan.-Apr. 1929, pp. 61–65, 7 figs. High-pressure turbine installation at Northeast station of Kansas City Power and Light Co. described; operating pressure of 1200 lb. at turbine throttle, and total temperature of 725 deg. used; it is believed that heat consumption of station will be lowered 1830 B.t.u. by operation of high-pressure equipment; with annual output of 530,201,400 kw-hr., and with fuel at 67,000 B.t.u. for one cent, saving in fuel will result in annual reduction in cost of $144,700. Paper presented before Midwest Power Eng. Conference.

Lubrication. Maintenance and Lubrication of Stationary Steam Turbines (Die Wartung und Schmierung der ortsfesten Dampfturbinen), G. Spettmann. Brennstoff u. Waermewirtschaft (Halle), vol. 11, no. 8, Apr. 2, 1929, pp. 133–136. Main requisites of first-class turbine oil is removal of elements from oil which cause decomposition or new combinations; best means of laboratory analysis is tarring coefficient of Kissling; acid content of oil is second factor of importance; viscosity of oil and other conditions governing successful turbine lubrication.

Turbine Lubrication, W. D. Jarvis. Elec. Times (Lond.), vol. 75, no. 1963, June 6, 1929, pp. 886–888. Points to be considered in efficient lubrication; tests to which samples of oil should be submitted; effects and decomposition produced by heating, oil spraying, presence of water, and foreign solid matter and alkaline solutions in mineral oils are considered; leakage of electric currents to oil system.

STEAMSHIPS

Pulverized Coal Fired. Pulverized Coal for Ships. Times Trade and Eng. Supp. (Lond.), vol. 569, no. 24, June 1, 1929, p. 283. Notes on alternative systems; in Berwindlea, Clarke-Chapman system of firing is being fitted, in which pulverizers are of Resolutor type consisting of high-speed impact-type mill driven by electric motor coupled to primary air fan that draws off powdered coal, returning any coarse coal to mill for further treatment; two vessels being built in America are to be fitted with Fuller-Lehigh system of firing, in which mill is of slow-speed ball type, comprising revolving drum partly filled with hard steel balls which effect necessary pulverization.

Turbo-Electric. Steam Turbine Electric Drive for Merchant Vessels. Am. Soc. Naval Engrs.—Jl., vol. 41, no. 2, May 1929, pp. 252–265, 4 figs. Characteristics of turbo-electric mode of propulsion for commercial ships; space, weight, fuel economy, reliability, operation, comfort of passengers and crew, auxiliaries, dual drive, and condensing plant are considered; application to S. S. Virginia; economy of turbo-electric installation, based on performance of S. S. Virginia, is compared with that of direct-drive Diesel job.

STEEL

Chromium. See CHROMIUM STEEL.

STEEL CASTINGS

Specifications. C.E.S.A. Issue Specifications on Carbon Steel Castings. Can. Machy. (Toronto), vol. 40, no. 12, June 13, 1929, pp. 39–40 and 72. Specification G28-1929, covering carbon-steel castings, published by Canadian Engineering Standards Association is given and discussed; specification covering manufacture, chemical properties and tests, physical properties and tests, workmanship and finish, inspection and rejection, and special requirements for castings for ships and for castings subject to heavy duty, such as rotating parts of machines and housings.

STEEL INGOTS

Casting. Casting of Steel Ingots (Das Giessen von Stahlbloecken), F. Pacher. Stahl u. Eisen (Duesseldorf), vol. 49, no. 18, May 2, 1929, pp. 627–643, 26 figs. Significance of casting in comparison with melting process; most important casting processes and their basic differences; thermal, metallurgical, and mechanical aspects; temperature conditions with casting and with solidification of different kinds of steel; significance of piping problem and its prevention; segregation and blowhole formation; oxidation during casting.

STEEL TESTING

Bending. Prolonged Bending Tests of Steels (Dauerbiegeversuche mit Staehlen), E. Houdremont and R. Mailaender. Stahl u. Eisen (Duesseldorf), vol. 49, no. 23, June 6, 1929, pp. 833–839, 8 figs. Relations between oscillating and tensile strength as well as between oscillating strength plus yield point are determined; influence of chemical composition, structure, and grain size, and of heat treatment and cold working; influence of surface properties on durability; notch effect.

STOKERS

Design. Modern Stoker Equipment, C. F. Hirshfeld and G. U. Moran. Fuels and Steam Power (A.S.M.E. Trans.), vol. 51, no. 1, Jan.-Apr. 1929, pp. 69–73, 11 figs. Improvements that have been made in stoker construction to adapt them to modern needs described; improved types are constructed carefully, are capable of accurate control, and are used in large sizes; in choosing stoker equipment it is recommended that generous allowance should be made above apparent maximum requirements for fuel feed. Paper presented before Midwest Power Eng. Conference.

STRUCTURAL STEEL

Oxyacetylene Welding. Building Erected by Gas Welding. Iron Age, vol. 123, no. 26, June 27, 1929, pp. 1762–1764, 5 figs. See also Iron Trade Rev., vol. 84, no. 26, June 27, 1929, pp. 1711–1712, 5 figs. Use of oxyacetylene welding in fabricating and erecting large factory building to be used for Research department at Niagara Falls plant of Union Carbide Co.; valuable data secured for future work along same line; field welding began in joining half-truss sections on ground; bolts at splice and ridge joints permitted bolt assembly of these sections; assembled trusses were laid flat on blocks along one side of aisle, each truss lapping other, so that welders could get at joints.

T

TOOL HOLDERS

Standardization. Toolholder Shanks and Toolpost Openings—American Standard. Am. Mach., vol. 70, no. 24, June 13, 1929, pp. 947, 4 figs. Standard given for toolholder shanks and tool-post openings which was developed by Sectional Committee on Standardization of Small Tools and Machine Tool Elements originally organized in September 1922, under procedure of American Standards Association, Society of Automotive Engineers, and American Society Mechanical Engineers; dimensions of tools and toolposts covered by Standard.

TOOL STEEL

Heat Treatment Specifications. Recommends General Procedure in Tool Steel Heat Treatment. Iron Trade Rev., vol. 84, no. 19, May 9, 1929, pp. 1262–1263, and 1267. Tentative general recommendation for heat treatment of tool steels prepared by American Society for Steel Treating; rate of heating charging furnace; large-size tools; uniform heating of tools; holding at heat; furnace atmosphere; effect on scale; thermocouples; quenching medium of oils, water, brine, and air; quenching; strains; uniform tempering; charging tempering furnace; rate of heating; cooling from tempering; tempering by color; cementite segregates; rates of heating and cooling.

TUNGSTEN

Properties. Tungsten as a Technical Material Chem. and Industry (Lond.), vol. 48, no. 23, June 7, 1929, p. 573. Progress has been made in electrolytic preparation of tungsten with feebly alkaline electrolyte of fused alkali tungstates; besides its use in lamp industry, metallic tungsten is employed for cores of carbon electrodes in electrolytic work, and for electrodes in arc welding; tungsten in alloys confers hardness and resistance to corrosion especially by acids; nickel and tungsten form number of important acid-resisting alloys; tungsten steel; process has been developed for pressing and sintering tungsten carbide; hard metal "Widia" is prepared in this way.

TUNGSTEN CARBIDE

Properties. Properties of Carbonized Tungsten, B. T. Barnes, Jl. of Phys. Chem., vol. 33, no. 5, May 1929, pp. 688–691, 5 figs. Paper deals with spectral and total emissivity and melting point of carbide of tungsten; measurements were made on tubular pressed filaments, before and after carbonization.

Cutting Tools. Carboloy—Remarkable New Cutting Tool Material, S. L. Hoyt. Can. Machy. (Toronto), vol. 40, no. 9, May 2, 1929, pp. 34–35, 3 figs. Possibilities of new tool material are discussed and reference made to experiments conducted with molded materials containing meta inserts, such as fabric gears used in automobiles. From Grits and Grinds.

Grinding of Tungsten Carbide Alloy Requires Care and Technique, A. H. Prey. Automotive Industries, vol. 60, no. 24, June 15, 1929, pp. 919. Discussion of grinding problems confronting user of tungsten carbide cutting tools; recommendations are made which are based upon experience of manufacturer of grinding wheels.

Recommended Practice in Grinding Tungsten Carbide Tools, A. H. Prey. Can. Machy. (Toronto), vol. 40, no. 10, May 16, 1929, pp. 36. Grinding problems confronting use of tungsten carbide cutting tools are discussed and recommendations based upon experiences of manufacturer of grinding wheels are made.

Tungsten Carbide Cutting Edge Renewed by Lapping Operation, S. M. Hershey. Automotive Industries, vol. 60, no. 25, June 22, 1929, pp. 951, 1 fig. Recommendations for putting cutting edge on tungsten carbide cutting tools; characteristic hardness of alloy actually places it in class comparable to precious stones; renewing its cutting edge with grinding is really lapping operation, calling for fine and soft wheel in preference to hard coarse wheel.

V

VALVES

Hydraulic. Penstock Valves. Nat. Elec. Light Assn.—Serial Report no. 289–72, May 1929, 21 pp., 19 figs. Review of current practice in use of valves, usually located in closed conduit, leading from open forebay or surge chamber to units of water-power plant; choice of type of valve; loss of head in valves; use of valves as meters; power required to operate valves; space required; relative cost; reliability in operation; leakage; emergency operation operating mechanism; details of design; statements by Allis-Chalmers Manufacturing Co. and others.

W

WARSHIPS

Diesel. The "Ersatz Preussen." Shipbldg. and Shipg. Rec. (Lond.), vol. 33, no. 23, June 6, 1929, p. 721. New German warship under construction by Deutsche Werke, Kiel, combines armament, armor, speed, and radius of action to extraordinary degree, while still conforming to 10,000-ton limit of displacement laid down by Treaty of Versailles; vessel carries six 11-in. and eight 5.9-in. guns, besides six torpedo tubes and minor armament; radius of action of 10,000 miles at 20 knots and maximum speed of 26 knots is expected; if realized, this radical development will influence trend of design and construction in merchant vessels.

IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

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What It's All About

AN INDUSTRIAL age must look to engineering for its leaders. The technical phases of modern industry require men who have been trained to understand the scientific fundamentals upon which it is based, but these men must also possess the universal qualities which have distinguished leaders in all ages. None but the best will do.

Training and education are essential in the development of both the natural and acquired endowments of industrial leaders. The formal period of schooling calls for the best methods, the best curriculums, the best teachers. The best human material must be selected to receive the benefits of the educational process.

After graduation comes the less formal part of training in the experiences of living. In his profession a man finds both the problems and the stimuli to conquer them. Professional societies exist to help in the process of post-collegiate training. MECHANICAL ENGINEERING, as the journal of a great engineering society, has an obligation and a responsibility in this field. This single-page résumé of the contents of the September issue tells "What It's All About."

An Experimental Approach

IT IS hard for a layman to understand the power of mathematical analysis. Get him beyond the simple arithmetic of his check book and he despairs of understanding you. There is a very natural basis for his suspicion that he is "being taken for a ride" when the mathematician offers an explanation of the structure of the unseen atom. It would be much more convincing to *see* a solar system of electrons than it is to follow a mathematical proof of its motion.

A scientist, too, likes experimental verification of his mathematical deductions. He finds the experimental approach invaluable. Oftentimes, when the number of variables affecting a result is too numerous, or when some of them may not be known, there is none but the experimental method for the investigator to try. Always he must use it to evaluate the constants and characteristic physical data.

In a paper in MECHANICAL ENGINEERING for September, R. V. Baud and R. E. Peterson make use of an interesting experimental method in attacking the problem of determining the conditions for favorable load and stress cycles when gear teeth are in contact. By making models of the teeth in celluloid and subjecting them to a beam of light, concentrations of stress in the teeth became visible as bands of different colors. The picture on the cover of the September issue indicates how these bands of color appear in an ordinary photograph.

Incidentally the paper is a typical example of the work which the research laboratories of modern manufacturing establishments are doing as they attack the problems that beset them. Without such work as this, progress would cease, and the creative elements of engineering would suffer paralysis. The financial success of industrial ventures depends largely upon the advantages in improved product and methods, and in decreased costs resulting from engineering research.

The Human Values

A SCULPTOR can model a clay man so cleverly that in form man and statue are identical; but in form only. The statue has no vitalizing spirit. As sculptors in the creative art of industry, engineers are frequently accused of placing a greater stress upon the physical aspects of their works than upon their humanistic features. Having substituted a new civilization, based on science, for the older forms of society which antedated the age of Watt, the engineer has been criticized as having destroyed something of beauty and value, while his machine age is frequently looked upon by bewildered laymen as the juggernaut that will eventually destroy every one.

Ralph E. Flanders, in an address published as the leading article in MECHANICAL ENGINEERING for September, assumes the role of the protagonist of the engineer. Accepting the old-fashioned qualities of beauty, truth, and goodness, Mr. Flanders applies them as measuring sticks to the present situation and to engineering, and finds a new and vigorous significance to the contributions which the engineer has made toward a civilization.

Mr. Flanders' interpretation of the new culture which frankly acknowledges the helpful influences and the enormous potentialities of science and faces them without the mystic fear of ignorance, serves to explain the engineer to himself and to his fellow men, and gives expression to the noble ideals of the engineering profession.

Helium for Airships

RECENT trips of the *Graf Zeppelin* to this country have stimulated once more interest in lighter-than-air craft, and speculation as to the commercial possibilities offered by this method of transportation.

Airships float in the air because of the buoyancy of the "lifting gas" which is contained in their huge bodies. The lighter the gas, the greater will be the lifting force of the airship and the greater will be its pay load in commercial flight.

Hydrogen, as every one knows, is the lightest of all gases, and hydrogen is used to fill the gas cells of the *Graf Zeppelin*. But hydrogen is a dangerous gas, being highly inflammable. Many of the tragic experiences of aeronautics have been caused by the burning up of a hydrogen-filled balloon or dirigible.

The next lightest gas is helium, happily inert, but unfortunately difficult to procure. In fact it was thought at

one time to exist only in the sun, and hence its name was derived.

In the September issue of MECHANICAL ENGINEERING, R. R. Bottoms, in an article entitled "The Production and Uses of Helium Gas," tells an interesting story about this valuable gas used by the U. S. Navy for inflating its airships. Fortunately for this country, the natural gas found in certain fields, notably in Kansas, Texas, and Colorado, contains amounts of helium which can be recovered on a commercial basis. Mr. Bottoms discusses many important phases of the helium-gas industry.

Nitridation of Steels

METALS that machine readily are likely to wear excessively. There are two well-known remedies for this condition of affairs; first, to use a metal which can be hardened after machining by means of a heat-treatment process; second, to harden the wearing surface of the machined piece.

The first method has the disadvantages that the materials used are fairly costly alloy steels and the hardened object may become too brittle for practical use. By hardening the exterior surface only, a tough interior may be combined with a glass-hard wearing surface.

H. W. McQuaid, metallurgist of the Timken-Detroit Axle Co., Detroit, writes in the September issue of MECHANICAL ENGINEERING on "Surface Hardening of Steel by Nitrogen." He states briefly what the nitriding process is, what materials are required, what the disadvantages are, how it can be tested, and to what applications it is most suitable. From an engineering standpoint, Mr. McQuaid says, serious consideration should be given to the use of nitriding steels as a means of combating corrosion and eliminating wear and distortion.

Installing Hydroelectric Units

MODERN hydroelectric machinery runs to great size so that it is impossible for the manufacturer to assemble it completely in his shops for inspection and testing prior to shipment. Adjustments which may be made to small-size apparatus in the shop must be made to large-size apparatus in the field. Errors are costly, and therefore consideration must be given during the design of the machinery to factors that will make corrections in the field as easy as possible.

This is the subject to which Charles V. Foulds gives his attention in a paper read at the Semi-Annual Meeting of the A.S.M.E. held in Salt Lake City, July 1 to 4, and published in MECHANICAL ENGINEERING for September. The paper is entitled "Modern Practice in the Installation and Starting of Hydroelectric Units."

Mr. Foulds concludes that no amount of engineering supervison or careful layout of tools and methods of assembly can possibly be a substitute for a man of the broadest experience to direct personally and intimately all of the assembly work down to the smallest details. This conclusion should be thoughtfully pondered by those who fear that the automaton is destined to replace the human worker with a trained intelligence and skill in the handling of tools.

Natural Sources of Power

THE ability to substitute mechanical for muscular power in the performance of almost every task differentiates our civilization from those of past epochs and is the basis for an era of human happiness such as the world has never before seen. To power we owe much if not all of the easing of human burdens where men do the day's work.

Every once in a while it is profitable to consider thoughtfully the sources of power and to speculate on their development on such a scale as to be commercially profitable. Such an attempt was made by a visiting scientist, F. M. Jaeger, of Groningen, Holland, in a public lecture delivered at Cornell University. Parts of the address which affect most closely the interests of the engineer have been published in MECHANICAL ENGINEERING for September in an article entitled "The Present and Future State of Our Natural Energetic Resources."

We naturally think of coal, of falling water, and of certain liquid and gaseous fuels as our natural sources of power as indeed they are. Dr. Jaeger, however, is concerned in the present article with less common resources. He mentions the power from tides, and from the low-pressure steam plant with which Georges Claude is experimenting, which utilizes the differences of temperature of surface and deep water in tropical seas. Then there is the energy to be derived by the radiant heat from the sun, and that which may be stored up by a photochemical reaction in chemical energy. The photochemical process, according to Dr. Jaeger, contains interesting and hopeful possibilities. When mankind's existence is threatened by a shortage of energy, it will be the physicist and the chemist who will rescue him from his predicament by developing these still speculative sources of power.

Engineering Executives

MORE than two-thirds of the graduates of engineering colleges are occupying administrative positions fifteen years after graduation, according to the results of an investigation of the Society for the Promotion of Engineering Education. Training for the responsibilities of administrative and executive positions is therefore an important consideration of all engineers.

In the September issue of MECHANICAL ENGINEERING, W. L. Batt, himself an engineering graduate and executive head of an industry based on engineering, writes on the duties of a chief executive in a business of moderate size. The picture which Mr. Batt has drawn is an excellent one for the young engineer to copy.

Tennessee River Survey

IN THE September issue of MECHANICAL ENGINEERING, J. A. Switzer gives a brief résumé of the work done by the Corps of Engineers, U.S.A., in surveying the Tennessee River system on the basis of its development for navigation, flood control, and power development. The survey was commenced in 1922 and has cost to date more than a million dollars.